SYNOPSIS OF THE MORPHOLOGY AND TAXONOMY OF *CAREX* SECTION

GLAUCESCENTES IN NORTH AMERICA

A Thesis

by

DIANE COSTON MCLAUGHLIN

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

August 2004

Major Subject: Rangeland Ecology and Management

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Approved as to style and content by:

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ABSTRACT

The Morphology and Taxonomy of *Carex* Section

Glaucescentes in North America. (August 2004)

Diane Coston McLaughlin, B.S., Texas A&M University

Chair of Advisory Committee: Dr. Stephan L. Hatch

Field studies were used to characterize habitat and evaluate morphological characters of *Carex glaucescens, C. joorii* and *C. verrucosa*. Morphometric analysis of herbarium specimens along with field studies, Environmental Scanning Electron Microscopy (ESEM), pollen viability and phenology show *C. glaucescens*, *C. joorii* and *C. verrucosa* to be taxonomically distinguishable at the species level. The taxonomy of *Carex* section *Glaucescentes* is presented in an artificial dichotomous key to the taxa and in species descriptions.

DEDICATION

To the beginnings of every Botanist.

ACKNOWLEDGEMENTS

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I would like to thank several people whose correspondence made a valuable contribution to this work: Stanley D. Jones, Anton A. Reznicek; David Rosen, Dale A. Kruse, James Macklin; Thomas A. Zanoni, Jay Wipff, Kanchi Gandhi and Ernie Schuyler.

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INTRODUCTION

The Cyperaceae (sedge) family consists of 4500 to 5000 species (Reznicek 1990). This large cosmopolitan family contains 70 to 100 genera that are characterized as monocotyledons with linear, three-ranked, alternate or basal, flat or terete or triangular or absent leaves; basal sheaths with connate margins, ligulate or eligulate (Walters & Keil 1996). The family generally has bisexual flowers with highly reduced or absent perianth parts that are subtended by a bract. The two- to three-carpellate ovary matures into an achene (Standley 1981). The flowers are generally wind pollinated, with the exception of the few entomophilous taxa in *Carex*, *Cymophyllus* and *Rhynchospora* in North America.

Four subfamilies in the Cyperaceae are the Mapanioideae C.B. Clarke, Cyperoideae, Sclerioideae C.B. Clarke, and Caricoideae Pax (Jones 1994). Caricoideae is characterized by strictly unisexual florets (Goetghebeur 1985), which are subtended by partially or wholly closed perigynium of prophyllar origin (Blaser 1944). Caricoideae contains one tribe, the Cariceae Kunth *ex* Dumortier, which is comprised of 5 genera, including *Carex* (Reznicek 1990).

Carex comprises the majority of species within the Caricoideae subfamily (Reznicek 1990). *Carex* is separated from other genera in the Caricoideae by a completely closed perigynia and a reduced to absent rachillas. *Carex* species are often dominant in wetlands, pastures, prairies, tundra and the herb layer of temperate forests (Catling et al. 1990). *Carex* contains about 500 (Catling et al. 1990) to 600 (Hermann 1954) species in North America and as many as 2000 worldwide (Catling et al. 1990). The number of North American hybrid taxa reported in *Carex* is 253

This thesis follows the format of Sida, Contributions to Botany.

(Cayouette & Catling 1992), however 70 hybrid taxa are commonly recognized. Hybridization within the family has been ignored, partially due to numerous, sometimes erroneous, reports of hybrids in old monographs and floristic lists as well as the difficulty of delimiting hybrid taxa and the differing views of botanists such as Mackenzie and Fernald (Cayouette & Catling 1992). The majority of recent taxonomic research in the Cyperaceae has been in the genus *Carex* (personal communication Jones 2001). Current research indicates the highest propensity for hybridization is in the subgenus *Carex* (Cayouette & Catling 1992).

The three *Carex* subgenera recognized by Reznicek (1990) are *Vignea*, *Carex* and *Indocarex*. Kükenthal (1909) included a fourth subgenus, *Primocarex*, which is considered an artificial grouping (Reznicek 1990). Vignea is separated from other subgenera based on the absence of cladoprophylls, presence of an abaxial false suture and lateral inflorescence subunits that are generally sessile (Reznicek 1990). *Carex* and *Indocarex* subgenera are separated from each other based on the presence or absence of inflorescence prophylls and lateral inflorescence subunits (Reznicek 1990). Reznicek (1990) depicts the *Carex* inflorescence with lateral inflorescence units that depending on the subgenus contain spikes (lateral inflorescence subunits). Reznicek (1990) also refers to the single flowered perigynia as a spikelet. Within this manuscript lateral inflorescence subunits will not be further discussed and inflorescence units will be referred to as spikes.

Carex glaucescens S. Elliott, *C. joorii* L.H. Bailey, and *C. verrucosa* G.H. Muhlenberg are in section *Glaucescentes* of the genus *Carex* (Reznicek 2001). Based on subgenera characters listed by Reznicek (1990), these taxa are placed in the subgenus *Carex*. *Carex brasiliensis* St. Hilaire is also included in section

Glaucescentes; however, it is a South American species and is excluded from this study due to logistics and a clear morphological separation from the other three taxa. *Carex brasiliensis* is reported to differ from the North American taxa by having more lateral spikes (9) and flattened perigynia (Boott 1860). These North American taxa are distributed from East Texas to Maryland along the southeast coast of the United States and inland from Arkansas to Tennessee. They occur in cypress-gum ponds and depressions, seasonally wet pine savannas, flatwood ponds, branch bays, adjacent ditches, swales, floodplain forests, bottomland woodlands, marshy shores and often in shallow water (Godfrey & Wooten 1979). Reznicek (2001) described the section *Glaucescentes* as follows:

> Cespitose in large, leafy clumps, rhizomes short and stout; basal sheaths coriaceous, brown to dull reddish purple. Culms central, 50-150 cm tall. Leaves 5 to 15, M-shaped in cross section, glaucous and ± papillose beneath; sheath fronts brownish hyaline, finely brown-dotted. Inflorescences 10-40 cm, with 3 to 8 spikes, terminal spikes staminate, lateral spikes pistillate or the distal 1 or 2 staminate or androgynous, peduncled, erect or pendent; proximal bracts leaf-like, exceeding the inflorescence, sheathless or short-sheathing. Pistillate scales acute to retuse, awned. Perigynia ascending or spreading, narrowly ovoid to broadly obovoid, rounded-trigonous to flattened-elliptic in cross section, strongly to weakly nerved, papillose, tapering or contracted to a short, entire or weakly bidentulate beak, stigmas 3, anthers 3, reddish.

Elliott (1824) described *C. glaucescens* and did not designate a type specimen. *Carex glaucescens* material examined by Elliott was not located in the literature or herbarium material. Bailey (1886) described *C. joorii* from a Joor collection [Holotype: Louisiana, Comite Swamp, near Baton Rouge, 5 Aug 1885, J. F. Joor s.n. (BH)]. *Carex verrucosa* was listed by Muhlenberg (1813) in a checklist of North America. Muhlenberg (1817) provided a description for *C. verrucosa*, thus validly publishing the name, but did not designate a type specimen.

Boott (1860) was the first to group *C. brasiliensis* with *C. glaucescens* and *C. verrucosa* at the sectional level. Boott (1860) acknowledged Drejer's 1844 placement of these taxa in *Carex* section *Aeorostachyae*. Kükenthal (1909) placed *C. joorii* in section *Maximae* (Ascherson) Kükenthal and *C. glaucescens* , *C. verrucosa* and *C. brasiliensis* in section *Paludosae* G. Don. Reznicek (2001) disagreed with Kükenthal's placement of the taxa based on their sheathless or short sheathing bracts compared to section *Maximae* and cespitose habit compared to most species in the *Paludosae*. Mackenzie's (1935) North American treatment placed *C. glaucescens*, *C. joorii* and *C. verrucosa* in *Carex* section *Pendulineae*. Mackenzie (1935) included *Carex flacca* in his treatment of the section *Pendulineae*, however Reznicek (2001) reported *C. flacca* as unrelated based on it being smaller, having elongate creeping rhizomes, scabrous hispid perigynia and awnless pistillate scales. Reznicek (2001) placed *C. glaucescens*, *C. joorii*, *C. verrucosa* and *C. brasiliensis* in section *Glaucescentes* because of their papillose perigynia and basal staminate flowers of the pistillate spikes.

Differentiation between species in the *Glaucescentes* section is difficult due to similarities and indistinct delimitations that contribute to the confusion concerning species identification and their distribution. Until recent, the distribution of *C. verrucosa* in Texas was unclear. In Texas, Correll and Johnston (1970) excluded *C. verrucosa*, citing it as erroneously being reported in Texas. Gould (1975) included *C. verrucosa* as occurring in Texas. Godfrey and Wooten (1979) included *C. verrucosa* in their work, but as not occurring in Texas. Bridges & Orzell (1989) reported C. verrucosa from several southeastern Texas Counties. Jones et al. (1997) considered *C. verrucosa* as present in Texas from the examination and collection of specimens (personal communication Jones 2001). Standley (2002) also mapped C. verrucosa as being present in Texas. Clarification of the characters that delimit these taxa will increase accuracy in identifications and make distributions easier to define.

Carex joorii is separated from *C. glaucescens* and *C. verrucosa* by a pistillate scale that tapers distally into an acuminate to aristate apex and strong veins on the perigynia (Godfrey & Wooten 1979). These characters distinguish *Carex joorii* as a separate species; however it is important to include *C. joorii* in the study because it is in the section *Glaucescentes*. *Carex glaucescens* and *C. verrucosa* are differentiated, in several keys (e.g., Godfrey & Wooten 1979, personal communication Jones 2001) by drooping or erect peduncles, peduncle length, and frequently androgynous versus frequently pistillate spikelets. The degree to which a peduncle is erect or drooping varies and leads to subjective interpretation, thus increasing the difficulty of obtaining accurate identifications. These characters are indistinct between taxa are not desirable for taxonomic keys. Quantitative characters which more effectively separate taxa are preferable.

Objectives of this study were to define character and character states that help delimit the taxa, produce a dichotomous key for identification supported by statistical analysis of morphological data that will increase accuracy in identification of *C. glaucescens*, *C. joorii*, and *C. verrucosa*, determine the nomenclatural rank of the three North American taxa within *Carex* section *Glaucescentes*, examine herbarium, field and type specimens, add to the taxonomic knowledge pertaining to *Carex* and review pertinent taxonomic literature.

METHODS

Methods for evaluation of taxonomic ranking within *Carex* section *Glaucescentes* concentrated on gross plant morphology. Other methods used to support morphological findings included cytology, micromorphology, phenology and evaluation of taxa distributions. Results from these areas were used to characterize the taxonomy of North American taxa within *Carex* section *Glaucescentes*.

Fourteen herbaria loaned a total of 1,495 specimens of *C. glaucescens*, *C. joorii*, and *C. verrucosa* (Table 1) to the S.M. Tracy Herbarium (TAES) for this study. The selected herbaria represent the collective geographic distributions of these taxa. To provide a complete treatment of the North American taxa in *Carex* section *Glaucescentes*, it is necessary to locate or designate type specimens for valid taxa. Type specimens were located, when possible, for comparison with type descriptions and borrowed specimens. Taxon descriptions were evaluated for holotype designation, so that an exact specimen could be requested. When no type specimen was designated in the original protologue, taxonomic literature was searched to locate repositories of the publishing author. Requests to those herbaria for material were made.

If no type specimen for a valid taxon was designated at the time of publication, specimens were considered for typification. Selection of specimens for typification were based on rules from Article 9 of the International Code of Botanical Nomenclature (ICBN) (Greuter et al. 2000). Any specimen chosen to serve as a type specimen within this manuscript is not validly published here and must be validly published in accordance with the ICBN (Greuter et al. 2000). If a specimen is selected from original material available to the author at the time of publication, the type specimen would be

TABLE 1. Herbaria lending specimens and specimen images to TAES for use in this study.

LENDING INSTITUTION	ACRONYM[1]	LOANED SHEETS	IMAGED SHEETS	STATES
L.H. Bailey Hortorium	BH*	1	0	NY
Herbarium of Charles T. Bryson	CTB[1]	146	0	MS
Duke University	DUKE	147	0	NC
University of Florida	FLAS	100	0	FL
Florida State University	FSU	45	0	FL
University of Michigan	MICH	142	0	MI
North Carolina State University	NCSC	52	0	NC
University of North Carolina	NCU	215	0	NC
University of Louisiana at Monroe	NLU	241	0	LA
New York Botanical Garden	NY***	11	1	NY
The Academy of Natural Sciences Herbarium	PH**	0	2	PA
Southern Forest Research Program	SFRP	23	0	LA
Southern Weed Science Research Center	SWSL	6	0	MS
S. M. Tracy Herbarium	TAES	55	0	TX
University of Texas - Austin	TEX/LL	101	0	TX
University of Alabama	UNA	50	0	AL
U.S. National Herbarium	US	160	0	DC
TOTALS		1495	3	

* Holotype of Carex joorii Bailey.
** Elliott 215, Carex verrucosa Muhl.
*** Imaged sheet is included in loaned sheets.
1 Acronyms follow Holmgren et al. (1990), excluding the personal herbarium of Charles T. Bryson (CTB).

considered a lectotype (Greuter et al. 2000). A neotype would be designated, if all of the original material on which the name of the taxon was based was missing (Greuter et al. 2000). Recommendations from the ICBN for typification include considering not all material in the author's herbarium was used to describe the taxon, exclusion of unscientific methods of purely selecting specimens based on collector or citation in the protologue and a critical knowledge of the taxon.

Literature concerning the family, genus, section and species was assessed for information with reference to taxon description, synonyms and characters. Synonyms for the currently accepted taxa were identified and their descriptions evaluated for distinguishing characters, taxon validity and character overlap. Specifically, characters were selected from taxa descriptions, keys and papers on *Carex* morphology including Bailey (1886), Boot (1860), Elliott (1824), Godfrey & Wooten (1979), Ford & Ball (1992), Mackenzie (1935), Muhlenberg (1817), Reznicek (2001), and Toivonen (1980). Subsequently, this led to a compilation of quantitative and qualitative characters (Table 2) for measurement and quantification from herbarium specimens. The data compiled from the 59 characters and selected herbarium specimens was used in the univariate and multivariate analysis.

The study initially included 60 herbarium specimens from each taxon. Random selection was constrained by ensuring that the selected specimens represented the geographic distribution for each taxon. Selected specimens were not measured if spikes were missing or inaccessibly mounted. Misidentified specimens were recoded prior to or during Principal Component Analysis (PCA) as the accepted taxon based on Jones (personal communication). Measured immature specimens were removed from the PCA. The coherence to these methods resulted in an unequal number of

TABLE 2. Characters used in the analysis. Character states are: continuous quantitative (CQ), two-state quantitative (TS), two-state qualitative (TQ) and multiple-state qualitative (MS).

CHARACTERS	SYMBOL	UNIT OF MEASURE	CHARACTER STATE
INFLORESCENCE			
Inflorescence sex	IS	—	MS
Inflorescence length from base of low ermost sheath to apex of terminal spike	IL	cm	CQ
(Terminal spike)			
Length of spilke [a]	SLS	cm	CQ
Length of peduncle from base of uppermost terminal spike to base of sheath of uppermost pistillate spike	SLP	cm	CQ
Length from base of scale to aw n apex, removed from the upper portion of the low er fourth of terminal spike	SLSC	mm	CQ
Widest point of scale removed from the upper portion of the low er fourth of the terminal spike	SWSC	mm	CQ
Width of spike at middle point	SWSP	mm	CQ
Spike sex	SS	—	MS
Length of staminate portions of terminal spike	SLSP	mm	CQ
Length of pistillate portions of terminal spike	SLPP	mm	CQ
(Lateral pistillate spikes)			
Length of second low ermost pistillate spike peduncle [b]	PLLP	cm	CQ
Length of uppermost pistillate spike peduncle [b]	PLUP	cm	CQ
Ratio of PLLP to PLUP	PRP	—	CQ
Length of second low ermost pistillate spike [a]	PLLS	cm	CQ
Second low ermost pistillate spike staminate portion; located proximally, distally, both or absent	PSLS	—	MS
Length of uppermost pistillate spike peduncle [b]	PLUS	cm	CQ
Uppermost pistillate spike staminate; portion; located proximally, distally, both or absent	PSUS	—	MS
Ratio PLLS to PLUS	PRS	—	CQ
Average length of uppermost and second low ermost peduncles	PALP	cm	CQ
Average length of uppermost and second low ermost spikes	PALS	cm	CQ
Number of lateral spikes, excluding reduced spikes	PN	—	CQ
Number of lateral spikes w ith staminate spikelets	PNS	—	CQ
Pistillate scale apex shape	PHC	—	MS
Length from base of scale to aw n apex, randomly removed from lateral spikes	PLC	mm	CQ
Widest point of pistillate scale, randomly removed from lateral spikes	PWC	mm	CQ
Length of pistillate scale aw n, randomly removed from lateral	PLCW	mm	CQ

TABLE 2. Continued.

CHARACTERS	SYMBOL	UNIT OF MEASURE	CHARACTER STATE
(Low ermost lateral spike)			
Length of spike [a]	LLS	cm	CQ
Length of peduncle [b]	LLP	cm	CQ
Peduncle pendulous or erect	LDE	—	TQ
Length of distal staminate portion	LLSD	mm	CQ
Staminate spikelets present or absent	LS	—	TQ
Staminate spikelets located proximally, distally, both or absent	LSPDB	—	MS
(Reduced spike)[c]			
Number of achenes	RNA	—	CQ
Spike sex	RSS	—	MS
Number of reduced spikes	RNS	—	CQ
Length of reduced spike [a]	RLS	mm	CQ
Spike pedunculate or sessile	RPSS	—	TS
Length to base of terminal spike	RLBS	mm	CQ
(Achene)			
Length of achene from base above possible residual stipitate portion of perigynia to apex of style	ALWS	mm	CQ
Length of achene from base above possible residual stipitate portion of perigynia to base of style	ALWOS	mm	CQ
Widest point of achene	AW	mm	MS
Ratio of ALWOS to AW	ARLW	—	CQ
Length of style	ALS	mm	CQ
Achene surface texture	AT	—	MS
Achene shape	AS	—	MS
Location of w idest point of achene	AWP	—	MS
(Perigynia)			
Length of perigynia from base of stipitate base to apex of beak	GL	mm	CQ
Length of perigynia beak from abrupt angle change betw een beak and body of perigynia to apex of beak	GLBK	mm	CQ
Basal shape or perigynia	GHBS	—	MS
Number of nerves on perigynia faces	GNN	—	CQ
Nerves conspicuous or inconspicuous	GCI	—	TQ
Perigynia shape	GH	—	MS
Width of perigynia stipitate base	GWB	mm	CQ
Length of perigynia stipitate base	GLB	mm	CQ
Perigynia texture	GT	—	MS
Widest point of perigynia	GW	mm	CQ
Location of w idest point of perigynia	GWP	—	MS
Perigynia color	GC	—	MS

TABLE 2. Continued.

CHARACTERS	SYMBOL	UNIT OF MEASURE	CHARACTER STATE
PHENOLOGY			
Collection date	FD	—	CQ
VEGETATIVE			
Culm length from apex of rootstock to apex of inflorescence	HP	cm	CQ
Sheath auricle shape	AURI	—	MS

a spike length w as measured from the apex of the uppermost scale to the base of the low est scale
b peduncle length is measured from base of spike, denoted by low est scale, to base of spike sheath
c reduced spikes w ere considered those at the base of the terminal spike w ith less than 5 achenes

specimens available for study for each taxon. The 117 herbarium specimens or Operational Taxonomic Units (OTU's) used for data analysis are listed in Table 3.

Field Work

Location data from herbarium labels aided in the location of populations for field studies. Specimens were collected from 16 populations (Table 4). Research in the field centered on plant habit and taxon variation. Characters evaluated during field collection included exposure to the sun, orientation of lowermost pistillate spike peduncle and soil type.

A representative soil description was recorded at one site for each taxon (Table 5). Soil descriptions were recorded to aid in habitat description. Soil characteristics and sampling procedures were taken from Schoeneberger et al. (2002). The characters of depth, matrix color, texture, structure, redoximorphic depletion characters, iron or manganese concentration characters and iron and manganese concretions within upper horizons were recorded.

Cytology

Chromosome Numbers

Mitotic and meiotic chromosome counts were attempted. Mitotic counts were made from greenhouse grown specimens. Seeds obtained from field collections successfully germinated after removing a portion of the seed coat. Root tips collected from the greenhouse grown specimens were pretreated with alpha-bromonaphthalene to increase the frequency of cell divisions in metaphase and to aid in accurately counting chromosomes. Specimens were rinsed with distilled water (d. H_2O) and fixed

TABLE 3. Specimens used in the numerical analysis and scanning electron microscopy.

TAXA CODE	HERBARIUM AND ACCESSION NUMBER		COLLECTOR	COLLECTOR NUMBER	STATE	COUNTY	COLLECTION DATE
g01	CTB	—	J.R. MacDonald	2673	AL	Houston	23 Jun 1991
g02	CTB	—	J.R. MacDonald	2959	AL	Houston	3 Aug 1991
g03	CTB	—	R.F.C. Naczi	3305	AL	De Kalb	2 Aug 1993
g04	CTB	—	R. Kral	51209	AL	Pike	10 Jun 1955
g05	CTB	—	R. Kral	81288	AL	Bibb	15 Aug 1994
g06	CTB	—	C.T. Bryson	10147	MS	Lowndes	12 Aug 1990
g07	CTB	—	C.T. Bryson	14943	MS	Greene	25 Jul 1995
g08	CTB	—	S. McDaniel	26438	MS	Lamar	28 Aug 1982
g09	CTB	—	S. McDaniel	28031	MS	Hancock	25 Aug 1984
g10	DUKE	365024	J.W. Horn	135	GA	McIntosh	20 Aug 1997
g11	DUKE	164377	D. Demaree	32583	MS	Stone	5 Aug 1952
g12	DUKE	41857	H.T. O'Neil	8506	MS	Jackson	15 Sep 1937
g13	DUKE	99627	A.B. Seymour	91828	MS	Jackson	14 Aug 1989
g14	DUKE	363728	J.W. Horn	1400	NC	Moore	21 Aug 1998
g15	DUKE	14116	W.B. Fox	2812	NC	Bertie	23 Jul 1949
g18	FLAS	131823	K.D. Perkins	360	FL	Okaloosa	24 Jul 1977
g22	MICH	—	R. Kral	85572	AL	Grenshaw	20 Jul 1990
g23	MICH	—	H.H. Bartlett	1031	GA	McDuffe	25 Aug 1907
g24	MICH	—	J.B. Nelson	13281	SC	Clarendon	21 Jul 1992
g25	MICH	—	J.B. Nelson	14748	SC	Sumter	20 Aug 1993
g26	MICH	—	S.D. Jones	10393	TX	Newton	4 Nov 1993
g27	NCU	6575	J.R. Bozeman	5812	GA	Tattnall	12 Jul 1966
g30	NCU	6565	J.R. Bozeman	10549	GA	Charlton	26 Jun 1967
g31	NCU	6578	J.W. Thieret	36143	LA	Livingston	5 Aug 1958
g32	NCU	6584	K.E. Rogers	1372	MS	Forrest	29 Aug 1969
g34	NCU	6393	T.D. Nifong	597	NC	Robeson	23 Sep 1994
g35	NCU	6458	H.E. Ahles	33293	NC	Bladen	7 Aug 1957
g36	NCU	6469	H.E. Ahles	35790	NC	Duplin	7 Nov 1971
g37	NCU	6504	A.E. Radford	38840	NC	Washington	6 Aug 1958
g38	NCU	6474	H.E. Ahles	48285	NC	Gates	21 May 1949
g42	NLU	207716	K.H. Kessler	2381	LA	Winn	6 Aug 1982
g44	NLU	377787	C. Allen	18200	LA	Washington	14 Aug 1995
g45	NLU	377785	C. Allen	18202	LA	St. Tammany	15 Aug 1995
g46	NLU	191283	D. Thomas	78118	LA	Vernon	30 May 1992
g48	TAES	207534	R. Carter	10347	GA	Liberty	12 Aug 1992
g50	TAES	188980	S.&G. Jones	3707	TX	Tyler	17 Aug 1989
g51	TAES	159349	J.W. Kessler	4958	TX	Newton	22 Aug 1981
g52	USNAT	817421	J.D.S.	s.n.	AL	Butler	21 Aug
g53	USNAT	2310281	D. Demaree	32512	MS	Harrison	4 Aug 1952
g54	USNAT	1838039	R.K. Godfrey	1340	SC	Lexington	8 Aug 1939
g55	USNAT	3306756	C.N. Horn	5436	SC	Richland	21 Jul 1992
g58	UT	—	S.L. Orzell	8306	TX	Angelina	26 Aug 1988
g61	NCU	6418	A. McCrary	717	NC	New Hanover	27 Jul 1963
g62	TEX-LL	—	S.L. Orzell	12484	FL	Santa Rosa	21 Sep 1989
g63	TEX-LL	—	S.L. Orzell	12502	FL	Okaloosa	21 Sep 1989
g64	CTB	—	R. Carter	10347	GA	Liberty	12 Aug 1992
g66	CTB	—	C.T. Bryson	14554	MS	Jackson	16 Oct 1994
j01	DUKE	375748	J.R. MacDonald	13294	AL	Geneva	26 Jul 1999

TABLE 3. Continued.

TAXA CODE	HERBARIUM AND ACCESSION NUMBER		COLLECTOR	COLLECTOR NUMBER	STATE	COUNTY	COLLECTION DATE
j02	DUKE	160162	R. Kral	1638	FL	Gadsden	14 Oct 1955
j03	DUKE	365151	M.H. Alford	1470	MS	Amite	12 Sep 1998
j04	FLAS	195370	S.L. Orzell	20304	AL	Houston	1 Aug 1992
j05	FLAS	156912	J.R. Burkhalter	9724	FL	Santa Rosa	17 Oct 1984
j06	FLAS	195371	S.L. Orzell	20026	FL	Lafayette	7 Jul 1992
j07	LL	—	A.E. Radford	44342	NC	Nash	8 Sep 1975
j09	LL	—	F. R. Waller, Jr.	256	TX	Nacogdoches	11 Aug 1964
j10	LL	293013	R.S. Mitchell	3958	TX	Harrison	25 Aug 1967
j11	LL	293011	S.L. Orzell	11373	TX	Wood	5 Aug 1989
j12	LL	—	C. L. Lundell	14092	TX	Newton	18 Jul 1945
j13	LL	293017	B. C. Tharp	43268	TX	Angelina	9 Sep 1961
j14	LL	—	V. L. Cory	54744	TX	Jasper	2 Aug 1961
j16	NCU	6411	L. S. Beard	1423	NC	Lee	23 Aug 1956
j17	NCU	6407	L.J. Musselman	4113	NC	Gates	17 Oct 1970
j18	NCU	6410	A.E. Radford	27811	NC	Johnston	7 Aug 1957
j20	NCU	6423	A.E. Radford	39197	NC	Tyrrell	19 May 1974
j22	NCU	6434	S. W. Leonard	1938	SC	Jasper	9 Sep 1968
j23	NCU	6438	A.E. Radford	28365	SC	Williamsburg	22 Aug 1957
j24	NLU	128639	P. Laird	728	LA	Quachita	4 Aug 1974
j25	NLU	154800	S.E. Schutz	1767	LA	Rapides	6 Oct 1978
j26	NLU	227676	D.C. Moore	2520	LA	Union	4 Sep 1983
j27	NLU	340667	C.T. Bryson	10847	LA	St. Tammany	26 Aug 1991
j29	NLU	120446	R. D. Thomas	46104	LA	Quachita	1 Aug 1958
j30	NLU	294873	M.W. Palmer	889	NC	Durham	1 Aug 2386
j31	NLU	7943	R. D. Thomas	39724	TX	Liberty	23 Sep 1958
j32	TAES	207540	R. Carter	10268	GA	Bryan	4 Aug 1992
j33**	TAES	5700	S.M. Tracy	8475	MS	—	1 Aug 1903
j34	TAES	100028	F.R. Waller	256	TX	Nacogdoches	11 Aug 1964
j35	TAES	140005	D. Hartman	1274	TX	San Jacinto	27 Aug 1973
j36	TAES	202165	S.&G. Jones	3632	TX	Marion	5 Aug 1989
j37	TAES	202162	S.&G. Jones	3656	TX	Harrison	5 Aug 1989
j38	TAES	159345	J.W. Kessler	5100	TX	Harris	18 Sep 1981
j39	UNA	959	R.R. Haynes	6915	AL	Macon	24 Aug 1978
j40	DUKE	15388	H.L.B.	5474	NC	Harnett	16 Aug 1932
v01	CTB	—	J.R. MacDonald	5569	AL	Houston	19 Sep 1992
v02	CTB	—	J.R. MacDonald	5524	AL	Houston	12 Sep 1992
v03	CTB	—	J.R. MacDonald	5133	AL	Houston	22 Jul 1992
v04	CTB	—	J.R. MacDonald	4	AL	Geneva	11 May 1978
v05	CTB	—	R. Kral	80797	GA	Dougherty	9 Aug 1992
v08	CTB	—	C.T. Bryson	8021	GA	Lowndes	9 Jul 1988
v10	CTB	—	C.T. Bryson	4172	MS	Jackson	15 Apr 1986
v11	DUKE	65850	F.S. Earle	82	MS	Jackson	19 Jul 1889
v13	DUKE	137839	R.K. Godfrey	53496	FL	Leon	27 Mar 1956
v15	DUKE	205118	J.W. Thieret	25921	LA	St. Tammany	29 Apr 1967
v16	FSU	166923	L.C. Anderson	6703	FL	Franklin	24 Oct 1983
v17	FSU	164600	L.C. Anderson	6327	FL	Gadsden	25 Apr 1983

TABLE 3. Continued.

TAXA CODE	HERBARIUM AND ACCESSION NUMBER		COLLECTOR	COLLECTOR NUMBER	STATE	COUNTY	COLLECTION DATE
v19	FSU	146481	S.W. Leonard	6256	FL	Leon	7 Apr 1976
v20	FSU	182708	L.C. Anderson	12776	FL	Walton	24 May 1990
v21	FSU	176694	L.C. Anderson	10359	FL	Taylor	16 Apr 1987
v22	FSU	98176	S. McDaniel	6146	FL	Liberty	4 May 1965
v23	FSU	179695	J.R. Burkhalter	10596	FL	Escambia	8 May 1987
v24	FSU	76329	G.R. Cooley	8240	FL	Polk	3 May 1961
v25	FSU	144878	D.L. Martin	831	FL	Marion	26 Sep 1975
v26	NCU	6441	J.A. Lassiter	25076	FL	Hillsborough	20 May 1962
v27	NCU	6391	A.E. Radford	4274	NC	New Hanover	21 May 1949
v28	NCU	6395	H.E. Ahles	12547	SC	Allendale	13 May 1956
v29	NLU	351219	K. Northrup	s.n.	TX	Harris	26 Apr 1992
v30	UNA	1607	B. Hansen	7077	FL	Highlands	17 Apr 1980
v31	US	3167473	J.B. McFarlin	5807	FL	Park	15 Jun 1931
v32	US	3163427	J.B. McFarlin	5662	FL	Osceola	5 Jun 1931
v33	US	3163426	D.S. Correll	5310	SC	Georgetown	14 Jun 1936
v35	TEX-LL	—	S.L. Orzell	5787	LA	Allen	22 Sep 1987
v36	TEX-LL	293407	S.L. Orzell	5809	TX	San Jacinto	25 Sep 1987
v37	TEX-LL	293409	S.L. Orzell	5406	TX	Chambers	1 Jun 1987
v38	TEX-LL	293408	S.L. Orzell	8230	TX	Newton	23 Aug 1988
v39	TEX-LL	—	S.L. Orzell	8567	TX	Newton	26 Sep 1988
v40	TEX-LL	—	R.K. Godfrey	49189	NC	Brunswick	21 May 1949
v41	TAES	222971	L. Clayton	13	TX	Montgomery	16 Oct 1998
v42	FLAS	175458	W.T. Scudder	1687	FL	Volusia	27 Apr 1985
477*	TAES	—	D.C. McLaughlin	477	TX	Hardin	18 Jul 2002
522B*	TAES	—	D.C. McLaughlin	522B	TX	Newton	28 Jul 2002
511*	TAES	—	D.C. McLaughlin	511	TX	Orange	28 Jul 2002
521*	TAES	—	D.C. McLaughlin	521	TX	Newton	28 Jul 2002
518*	TAES	—	D.C. McLaughlin	518	TX	Newton	28 Jul 2002
508*	TAES	—	D.C. McLaughlin	508	TX	Newton	28 Jul 2002
436C*	TAES	—	D.C. McLaughlin	436C	TX	Tyler	24 May 2002
416B*	TAES	—	D.C. McLaughlin	416B	TX	Montgomery	22 May 2002
492*	TAES	—	D.C. McLaughlin	492	TX	Montgomery	25 Jul 2002
512****	TAES	—	D.C. McLaughlin	512	TX	Orange	28 Jul 2002
1612***	TAES	236082	D. Rosen	1612	TX	Montgomery	21 Aug 2001
71***	TEX-LL	—	S.L. Orzell	7104	LA	Calcasieu	30 May 1988
151***	TAES	234901	H. Amestoy	151	TX	Montgomery	16 Oct 1998
KN***	TAES	209301	K. Northrup	s.n.	TX	Harris	26 Apr 1992

* Personal collections used in both numerical analysis and environmental scanning electron microscopy.

** Borrowed specimens used in both numerical analysis and environmental scanning electron microscopy

*** Borrowed specimens used only in environmental scanning electron microscopy.

**** Personal collections used in both numerical analysis and environmental scanning electron microscopy.

TABLE 4. Personal collections of *Carex* section *Glaucescentes*. Specimens used in PCA and those that are possible hybrid taxa are indicated.

	LOCATION	TEXAS	TAXA AND COLLECTION NUMBERS**		
		County	*verrucosa*	*glaucescens*	*joorii*
1	E side of Hwy 69, 5.9 mi S of Village Creek, near Kountze	Hardin		477*, 478*, 479	
2	E side of Hwy 2798, N of Votaw, 3.1 mi S of intersection w/ FR 943	Hardin		504*	
3	E side of 69, N of Kountze, 1.8 mi N of intersection w/ 420, 0.2 mi N of Village Creek	Hardin		754A*,B*,C*, D*,E*	
4	Hwy 362, 1m SW of intersection w/ FR 1293	Hardin		755A*,B*	
5	E side of Hwy 943, 4.7 mi W of intersection w/ 1003 and 7.5 mi SE of Polk Co line	Hardin	650A,B,C,D		
6	W side of Hwy 62, 1.8 mi N of Orange Co line, N of Vidor, near Texla	Jasper		507A*,B	
7	N side of Hwy 105, 1.8 mi W of Peach Creek	Mont-gomery	407, 834*	473, 475*, 491*, 492*, 493, 494, 495*	471^{h}, 472^{h}, 835^{h*}, 836^{h}, 837^{h*}, 838^{h*}
8	N side of Hwy 105, 1.0 mile E of Peach Creek***	Mont-gomery	347A*,B,C*, 416A*,B*, 476, 831*, 832*, 833*		
9	W side of Hwy 62, .5 mi N of Orange Co line near Texla	Newton			508*

TABLE 4. Continued.

	LOCATION	TEXAS County	TAXA AND COLLECTION NUMBERS** *verrucosa*	*glaucescens*	*joorii*
10	S side of Hwy 12, 1.9 mi N of Orange Co line	Newton		517	518*, 519*, 520
11	W side of Hwy 87, 2.2 mi S of Slaydon Creek, 4.8 mi S of intersection w/ Hwy 2829	Newton		521*	
12	E side of Hwy 87, 3.6 mi S of intersection w/ Hwy 2829, small depression extending from ditch, near Bleakwood	Newton		522A*,B*	
13	E side of Hwy 87, 0.45 mi S of intersection w/ Hwy 2829, near Bleakwood	Newton		523	
14	N side of Hwy 12, 3.7 mi NE of iintersection w/ 62, under Myrica and Styrax shrubs, 1.0 mi SW of Newton Co line	Orange		511*, 513	510*, 512
15	N side of 943, several mi W of Hardin Co line	Polk		505	
16	FM 92, 7.9 mi N of intersection with FM 1112	Tyler	436A*,B,C*, 649A,B,C,D		

* Specimens used in PCA of personal collections and loaned herbarium specimens.
** Numbering procedures were not consistent, no inferences can be made from specimen numbering.
*** Plants present, with vegetative characteristics of *C. glaucescens* and *C. joorii*, but not in flower.
h Specimens considered as probable hybrid taxa.

TABLE 5. Representative soil descriptions of *Carex* section *Glaucescentes* from personal collections.

Carex glaucescens

Depth (in)***	Horizon	Matrix Color	Texture, Structure	Redoximorphic Depletions %,Sz, Cn, Col, Location	Fe or Mn Concentrations %,Sz, Cn, Col, Location	FeMn Concretions
0 - 2	A	10YR4/2	L, SBK	–	–	–
2 - 8	B	10YR5/3	L, SBK	F, F, P, 10YR 6/3, within peds	Fe: F, F, F, 10YR5/4, root channels & within peds	Present
8 - 16	B	10YR5/3	SIL, Moderate SBK	F, –, –, 10YR6/3, clay depletions within peds & on ped surfaces	Fe: M, F, F, 10YR6/6, within peds	Few, Fine

Original surface horizon has been removed.

Location: Texas. Polk Co., on E side of Hwy 2798, N of Votaw, 3.1 miles S of intersection with FR 943.

Carex joorii

Depth (in)***	Horizon	Matrix Color	Texture, Structure	Redoximorphic Depletions %,Sz, Cn, Col, Location	Fe or Mn Concentrations %,Sz, Cn, Col, Location	FeMn Concretions
0 - 1 1/2	Oi*	–	–, –	–	–	–
1 1/2 - 8 1/2	A	2.5Y3/2	SICL, SBK	C, –, –, 10YR6/2, –	Fe: F, F, –, 10YR5/6, root channels & within peds	–
					Fe: –, –, –, 2.5Y4/6, almost an amorphous Fe oxide	–
8 1/2 - 16	Eg	10YR5/2	SICL, SBK	–, –, –, 10YR6/2, clay depletions within peds	Fe: C, F, D, 2.5Y6/6, root channels	–

Location: Texas. Newton Co., on W side of Hwy 62, 0.5 miles N of Orange Co., line near Texla.

TABLE 5. Continued.

Carex verrucosa						
Depth (in)***	Horizon	Matrix Color	Texture, Structure	Redoximorphic Depletions %,Sz, Cn, Col, Location	Fe or Mn Concentrations %,Sz, Cn, Col, Location	FeMn Concretions
0 - 1 1/2	Overburden	Rubbed & Moist 10YR6/1 Dry 10YR3/1	L, –	Hydrophobic, waxy material on soil particles	–	–
1 1/2 - 4	Oe**	10YR2/1	Peat, –	–	–	–
4 - 10	A	10YR2/1	SIL, SBK	C, –, –, 10YR6/1	–	–
10 - 15 +	Eg	10YR5/2	L, SBK	C, –, –, 10YR6/2, clay depletions on ped faces	Fe: F, –, –, 2.5Y6/6, root channels	–

Location: Texas. Hardin Co., on Hwy 943, E side, 4.7 miles W of intersection w/ FM 1003 and 7.5 miles SE of Polk Co. line.

C. glaucescens, C. joorii, C. verrucosa						
Depth (in)***	Horizon	Matrix Color	Texture, Structure	Redoximorphic Depletions %,Sz, Cn, Col, Location	Fe or Mn Concentrations %,Sz, Cn, Col, Location	FeMn Concretions
0 - 1	A	7.5YR6/1	SIL, –	–	–	–
1 - 5	B	7.5YR5/2	CL, –	–	Fe: F, F, F, 7.5YR6/6, root channels & within	–
5 +	B	7.5YR6/1	CL, –	–	Fe: M, M, D, 7.5YR5/6, root channels & within peds	–

Location: Texas. Montgomery Co., on Hwy 105, 1.8 miles W of Peach Creek.

%	Percent of area covered.
Sz	Size.
Cn	Contrast.
Col	Color.
*	Fimbric: poorly decomposed.
**	Hemic: intermediately decomposed.
***	Recorded soil characteristics and abbreviations were taken from Schoeneberger et al. (2002).

with ethanol/glacial acetic acid (3:1). Enzymatic hydrolysis was used to digest cell walls and aid in chromosome spread. Prior to enzymatic hydrolysis specimens were rinsed four times and soaked for 30 minutes with d. H_2O, acidified with 0.1 N HCL for 10 minutes and rinsed twice and soaked for five minutes with d. H_2O. Root tips were dissected behind the meristem and placed in 0.5 ml microfuge tubes. The tubes also included the addition of a digestion enzyme mixture of 5% cellulose (Onazuka R-10, Yakult Honshu Co. Ltd., Tokyo, Japan) and 1% pectolyase Y-23 (Seichen Corp., Tokyo, Japan) prepared in citrate buffer (0.05, pH 4.5). Cell walls were digested away for an experimental series of 20-45 minutes at 68°C. Root tips were washed with d. H_2O four times, and single root tips were transferred to slides. Excess water was removed from around the root tip before adding one drop of fixative and macerating the material. Excess material was rinsed away with fixative after cells attached to the slide. Specimens were viewed either with no stain and phase contrast microscopy or stained with azure B and viewed with brightfield microscopy.

Meiotic chromosome counts were attempted from inflorescences fixed with ethanol/glacial acetic acid (3:1) in the field. Greenhouse grown specimens for mitotic counts never reached flowering stage and were not used. Anthers were removed from the fixative, washed and soaked in d. H_2O and transferred to a glass slide. Before macerating the anthers, aceto-carmine stain was added. Anthers were heated to aid in stain absorption by the chromatin. Before viewing, the cover slip was pressed down to spread cells and cell contents.

Pollen Stainability

Pollen stainability is one way to evaluate sexual reproduction and potential pollen viability. Mature pollen grains from each taxon, including suspected hybrids, were hydrated in d. H_2O and stained with Iodine-Potassium Iodide (IKI). Based on a count of 100 pollen grains per slide for each specimen, percent potential pollen viability was recorded for each taxon. Specimens used for pollen counts are listed in Table 6. Only pollen with intact exines were counted. Pollen staining a dark brown color tested positive for starch, which indicated the number of mature, viable pollen grains, since mature, viable pollen grains contain starch. Specimens were compared to Toivonen's (1980) research with infertile pollen grains of hybrid *Carex* specimens.

Achene and Perigynia Micromorphology

Achene and perigynia micromorphology were examined using Environmental Scanning Electron Microscopy (ESEM). The five specimens from each taxon used for ESEM (Table 3) were separated into the currently accepted taxa, based on Jones (personal communication). The protocol for laboratory procedures were used by Schuyler (1971), Menapace et al. (1986), Standley (1987a), Standley (1987b), Wujek and Menapace (1986), Catling et al. (1989) and Saarela and Ford (2001). The specimens, mounted on Scanning Electron Microscopy (SEM) stubs with double sided tape, were examined using an Electroscan E-3 Environmental Scanning Electron Microscope at an accelerating voltage of 30 KV.

Data Analysis

Univariate Analysis

The data matrix contained measurements and observations for 59 characters and 147 OTU's. Continuous variables were evaluated based on mean, standard deviation, variance, skewness and range using Statistical Package for Social Sciences 11.0 (SPSS). Continuous and discrete variables were evaluated graphically with box

TABLE 6. Pollen stainability. Percent viability was recorded for specimens; pollen staining a dark color were recorded as viable.

TAXA	PERCENT VIABILITY	POPULATION NUMBER*	POPULATION IS KNOWN TO CONTAIN**	PERSONAL COLLECTION NUMBER*
C. glaucescens	60%	14	G,J	511
C. glaucescens	74%	1	G	477
C. glaucescens	75%	12	G	522B
C. glaucescens	84%	7	G, J, V	492
Hybrid	3%	7	G, J, V	837
Hybrid	25%	7	G, J, V	835
Hybrid	30%	7	G, J, V	838
Hybrid	31%	7	G, J, V	473
C. jooriii	14%	9	J	508
C. jooriii	80%	14	G, J	510
C. verrucosa	5%	7	G, J, V	834
C. verrucosa	9%	16	V	649D
C. verrucosa	11%	5	V	650C
C. verrucosa	91%	8	V	831

* Location data are presented in Table 4.

** *Carex glaucescens* (G), *C. joorii* (J), *C. verrucosa* (V).

and whisker, histograms and scatter plots. After re-examining outliers to ensure their accuracy, some specimens were removed from the analysis due to specimen immaturity and missing values in the data matrix. The resulting data matrix contained 59 characters and 117 OTU's.

Multivariate Analysis of Borrowed Specimens

Numerical Taxonomy System 2.1 (NTSYS) was used for PCA. SPSS was used for Kaiser-Meyer-Olkin Measure of Sampling Adequacy. Correlation matrices from a standardized data matrix were used to create the principal components, which were plotted in Sigma Plot 8.0.

Qualitative and poor characters were removed from the multivariate data matrix. A PCA, with a reduced data matrix of 117 OTU's (47 *C. glaucescens,* 35 *C. joorii* and 35 *C*. verrucosa) and 26 characters, was used to clarify groups for a priori taxon labeling. Next, PCA's for each a priori group pairing were used to detect taxonomically important characters. The group pairing PCA's enabled the selection of taxonomically useful characters for the final PCA. Character selections for the final PCA were based on characters that graphically separated the taxa into groups while increasing the percent variation explained among OTU's. Characters were chosen by selecting at least three characters with the greatest eigenvector coefficients and/or those characters greater than or equal to 0.8 from each PCA a priori group pairing.

Geographic phenotypic variation was examined by labeling each OTU with state locality of specimen collection. State abbreviation labels were used to create artificial populations within each taxon. The resulting PCA was evaluated for clustering of taxa by single of multiple states. The data set was the same as that used for the final PCA of 10 characters and 117 OTU's.

Multivariate Analysis of Collected Populations Including Suspected Hybrids

Specimens collected were labeled by population and taxon based on Jones (personal communication). Personal collections of 19 *C. glaucescens* , 4 *C. joorii*, 9 *C. verrucosa* and 3 possible hybrid specimens were combined with the borrowed specimen data matrix of 117 OTU's and 10 characters. The subsequent data matrix contained 10 characters for 154 specimens. The resulting PCA was examined for differences between taxa, populations and phenotypic variation between regions.

Multivariate Analysis with Carex joorii Holotype Specimen

The *C. joorii* holotype specimen was measured and added to the data matrix of 117 OTU’s and 10 characters. The resulting matrix was then analyzed with PCA to ensure that the treatment of taxa aligned with the type. The resulting PCA was evaluated for orientation of the type specimen in relation to the other specimens of the same taxon.

<u>Taxa Distributions</u>

Distribution maps for *C. glaucescens, C. joorii* and *C. verrucosa* were created to clarify taxon distributions. Collection location data from annotated herbarium specimens were recorded and mapped in ArcView 8.0. Distribution maps were created from all borrowed herbarium specimens and those collected for this research with county and state location information.

<u>Phenology</u>

Several taxon descriptions conflict or altogether lack phenological information (e.g., Godfrey & Wooten 1979). Phenology was examined by coding specimen collection dates for all borrowed herbarium specimens 1 through 12 (univariate analysis) and 1 through 365 (multivariate analysis). Univariate analysis utilized histograms to compare taxon flowering dates by month. Flowering dates coded by Julian calendar day were used as a quantitative variable in the multivariate data analysis.

Species Descriptions

Most character ranges and states for the species descriptions were taken from the characters recorded for numerical analysis (Tables 2, 7-9). Other descriptive characters were measured and evaluated separately. Ranges for the descriptions are plus and minus one standard deviation (SD) from the mean (Tables 7-9). When one SD from the mean exceeded the lower or upper bound of the range of specimens measured, the minimum or maximum recorded value was used.

TABLE 7. *Carex glaucescens* univariate statistics from quantitative data used in PCA's and the taxon description.

CHARACTER[a]	n	UNIT OF MEASURE	RANGE	MINIMUM	MAXIMUM	MEAN	SD. DEV.	MEAN -1 SD. DEV.	MEAN +1 SD. DEV.
FD	47	—	137.0	174.0	311.0	229.9	28.2	201.7	258.1
IL	47	cm	21.1	7.9	29.0	14.6	3.8	10.8	18.3
HP	47	cm	91.8	58.4	150.2	96.4	17.4	79.0	113.8
SLS	47	cm	6.4	1.3	7.7	4.1	1.3	2.8	5.4
SLP	47	cm	39.3	0.3	39.6	5.0	6.9	0.3 *	11.9
SLSC	47	mm	7.2	1.3	8.5	6.3	1.3	5.0	7.6
SWSC	47	mm	4.0	1.0	5.0	1.5	0.6	1.0 *	2.2
SWSP	47	mm	4.8	4.1	8.9	5.9	1.2	4.7	7.1
PLLP	47	cm	9.8	0.0	9.8	2.3	1.6	0.7	3.9
PLUP	47	cm	6.2	0.0	6.2	1.6	1.1	0.4	2.7
PLLS	47	cm	4.2	2.1	6.3	3.7	0.9	2.8	4.6
PLUS	47	cm	3.9	0.4	4.2	2.7	0.8	1.9	3.6
PLC	47	mm	3.6	2.5	6.1	4.2	0.7	3.5	4.8
PWC	47	mm	1.0	1.0	2.0	1.4	0.3	1.1	1.7
PLCW	47	mm	2.8	0.5	3.3	1.4	0.6	0.9	2.0
LLS	47	cm	3.4	2.2	5.6	3.6	0.9	2.7	4.4
LLP	47	cm	11.7	0.5	12.2	3.2	1.9	1.3	5.2
GL	47	mm	1.7	3.0	4.7	3.7	0.4	3.4	4.1
GLBK	47	mm	0.5	0.2	0.7	0.4	0.1	0.3	0.5
GW	47	mm	0.7	1.8	2.5	2.2	0.2	2.0	2.4
GWB	47	mm	0.1	0.1	0.2	0.1	0.0	0.1	0.2
GLB	47	mm	0.1	0.1	0.2	0.1	0.0	0.1	0.2
LWP	47	mm	0.4	0.2	0.6	0.4	0.1	0.3	0.5
ALWOS	47	mm	1.1	1.9	3.0	2.5	0.2	2.3	2.8
AW	47	mm	0.6	1.7	2.3	2.0	0.1	1.8	2.1
GNN	47	—	8.0	2.0	10.0	4.9	2.1	2.8	6.9

a Character codes are in Table 2.

* Minimum or maximum range values are used if 1 standard deviation from the mean exceeds the range.

n Refers to the sample size.

TABLE 8. *Carex joorii* univariate statistics from quantitative data used in the PCA's and the taxon description.

CHARACTER[a]	n	UNIT OF MEASURE	RANGE	MINIMUM	MAXIMUM	MEAN	SD. DEV.	MEAN -1 SD. DEV.	MEAN +1 SD. DEV.
FD	35	—	151.0	139.0	290.0	231.6	29.7	201.9	261.3
IL	35	cm	21.0	7.5	28.5	18.7	5.4	13.3	24.1
HP	35	cm	95.3	23.5	118.8	80.3	18.4	61.9	98.7
SLS	35	cm	4.1	2.0	6.0	4.3	1.1	3.1	5.4
SLP	35	cm	5.9	0.3	6.2	3.0	1.5	1.5	4.6
SLSC	35	mm	4.2	4.9	9.1	6.3	1.2	5.1	7.5
SWSC	35	mm	0.7	1.1	1.8	1.4	0.2	1.3	1.6
SWSP	35	mm	7.0	2.5	9.5	4.6	1.3	3.4	5.9
PLLP	35	cm	4.7	0.6	5.3	2.4	1.2	1.2	3.6
PLUP	35	cm	2.7	0.0	2.7	0.5	0.5	0.0	1.0
PLLS	35	cm	4.4	2.3	6.7	3.9	1.0	2.9	4.9
PLUS	35	cm	4.7	0.8	5.5	2.5	0.9	1.6	3.4
PLC	35	mm	2.8	2.5	5.3	3.9	0.6	3.3	4.5
PWC	35	mm	0.9	1.2	2.1	1.5	0.2	1.3	1.7
PLCW	35	mm	1.3	0.3	1.6	1.1	0.4	0.7	1.5
LLS	35	cm	4.0	2.6	6.5	4.3	1.0	3.2	5.3
LLP	35	cm	5.8	2.0	7.8	4.4	1.8	2.6	6.2
GL	35	mm	1.5	3.4	4.9	4.0	0.3	3.6	4.3
GLBK	35	mm	0.7	0.7	1.4	1.0	0.1	0.8	1.1
GW	35	mm	1.0	2.1	3.1	2.7	0.2	2.5	2.9
GWB	35	mm	0.3	0.0	0.3	0.1	0.1	0.1	0.2
GLB	35	mm	0.2	0.0	0.2	0.1	0.0	0.0	0.1
LWP	35	mm	0.3	0.3	0.6	0.4	0.1	0.3	0.5
ALWOS	35	mm	0.6	2.3	2.9	2.7	0.2	2.5	2.8
AW	35	mm	0.9	1.9	2.8	2.4	0.2	2.2	2.6
GNN	35	—	8.0	12.0	20.0	14.8	1.4	13.4	16.2

a Character codes are in Table 2.
* Minimum or maximum range values are used if 1 standard deviation from the mean exceeds the range.
n Refers to the sample size.

TABLE 9. *Carex verrucosa* univariate statistics from quantitative data used in the PCA's and the taxon description.

CHARACTER[a]	n	UNIT OF MEASURE	RANGE	MINIMUM	MAXIMUM	MEAN	SD. DEV.	MEAN -1 SD. DEV.	MEAN +1 SD. DEV.
FD	35	—	200.0	97.0	297.0	172.5	62.5	110.0	235.1
IL	35	cm	25.2	8.5	33.7	20.0	7.7	12.3	27.7
HP	35	cm	93.2	63.4	156.6	99.5	19.2	80.2	118.7
SLS	35	cm	5.8	2.0	7.8	3.8	1.1	2.7	5.0
SLP	35	cm	30.5	0.3	30.8	6.0	8.4	0.3 *	14.4
SLSC	35	mm	6.8	4.9	11.7	6.7	1.4	5.3	8.0
SWSC	35	mm	1.9	0.7	2.6	1.5	0.4	1.1	1.9
SWSP	35	mm	12.0	3.5	15.5	7.5	3.2	4.2	10.7
PLLP	35	cm	2.5	0.2	2.8	1.1	0.6	0.6	1.7
PLUP	35	cm	1.2	0.0	1.2	0.2	0.2	0.0	0.5
PLLS	35	cm	3.7	1.5	5.2	3.6	1.0	2.6	4.5
PLUS	35	cm	2.9	0.8	3.7	2.2	0.8	1.4	2.9
PLC	35	mm	3.4	3.6	7.0	4.8	0.9	3.9	5.7
PWC	35	mm	3.0	1.1	4.1	1.6	0.5	1.1	2.0
PLCW	35	mm	3.3	0.4	3.7	1.6	0.7	0.9	2.4
LLS	35	cm	4.1	2.0	6.1	3.8	0.9	2.8	4.7
LLP	35	cm	7.8	0.7	8.4	2.9	1.8	1.1	4.7
GL	35	mm	1.4	3.2	4.6	3.8	0.4	3.4	4.2
GLBK	35	mm	0.8	0.1	0.9	0.4	0.2	0.2	0.6
GW	35	mm	0.9	2.2	3.1	2.5	0.2	2.4	2.7
GWB	35	mm	0.3	0.2	0.5	0.3	0.1	0.2	0.4
GLB	35	mm	0.3	0.2	0.5	0.3	0.1	0.2	0.4
LWP	35	mm	0.4	0.3	0.7	0.5	0.1	0.4	0.6
ALWOS	35	mm	1.0	2.2	3.2	2.6	0.2	2.3	2.8
AW	35	mm	0.9	2.1	3.0	2.5	0.2	2.3	2.6
GNN	35	—	12.0	4.0	16.0	11.1	2.7	8.5	13.8

a Character codes are in Table 2.
* Minimum or maximum range values are used if 1 standard deviation from the mean exceeds the range.
n Refers to the sample size.

RESULTS AND DISCUSSION

Cytology

Chromosome Numbers

Mitotic counts were not achieved because the pretreatment application was not developed adequately. Chromosomes were never viewed in metaphase, leading to the conclusion that results may be improved with a different or adjusted pretreatment method. Pretreatment methods can be adjusted by chemical type, concentration and application time, however, only application time was adjusted. The average digestion time for small roots was 35 minutes, which was increased or decreased for varying root sizes.

Definite meiotic chromosome counts were not obtained. Most field collections contained mature anthers with pollen grains, rather than those suitable for chromosome counts. Pollen grains were present in these specimens because collection was about a week too late. If specimens are collected after the majority of the staminate spikelets mature, it reduces the number of usable anthers. Within the staminate spike, the central spikelets mature first, followed by a few proximal and distal spikelets.

Pollen Stainability

Pollen viability, as estimated by pollen stainability with IKI, was consistently high for *C. glaucescens* ranging from 60-84% (Table 6). It was inconsistent for *C. joorii* ranging from 14-80% and *C. verrucosa* varied from 5-91%. Percent pollen viability was low for specimens considered to be hybrid taxa ranging from 3-31%. Low percent pollen viability was not correlated with hybrid taxa, because of the low pollen viability for some non-hybrid taxa. The varied pollen viability results cannot be used to definitively corroborate the existence of hybrid taxa.

Sexual reproduction among the taxa appears to vary, since low pollen viability was not solely aligned with hybrid taxa and high pollen viability was not always found in non-hybrid taxa. Because pollen viability results varied, further research within the section should evaluate other modes of reproduction such as apomixis. The rhizomonous habit of the taxa may be a primary mode of reproduction, if seed set is low from low pollen viability.

Achene and Perigynia Micromorphology

Achene micromorphology analysis yielded little useable taxonomic information because *Carex* achenes are better examined by methods that remove extraneous layers of cuticle prior to scanning electron microscopy. A misinterpretation of preliminary micrographs led to the conclusion that the cuticle and outer periclinal wall were absent and it was unnecessary to use cuticle and outer periclinal wall removal procedures. It is necessary to remove the cuticle and outer periclinal walls of *Carex* achenes because they are essentially devoid of useable taxonomic features (Menapace et al. 1986). Taxonomically pertinent features on the inner periclinal wall (lateral wall) of the epidermis (Menapace & Wujek 1987) are not detectable in the micrographs. The micrographs do exhibit central silica bodies and an alveolate cell shape in all three taxa (Figs. 1-2).

The perigynia micromorphology micrographs yield information that generally separates *C. joorii* specimens (Figs. 1-2) from other taxa. *Carex joorii* generally exhibits papillae that are reduced, appearing rounded over and sometimes absent with concave reticulate cells. Perigynia of most *C. joorii* have clavate papillae on the beak and reduced papillae covering the body. Some *C. joorii* specimens are entirely covered

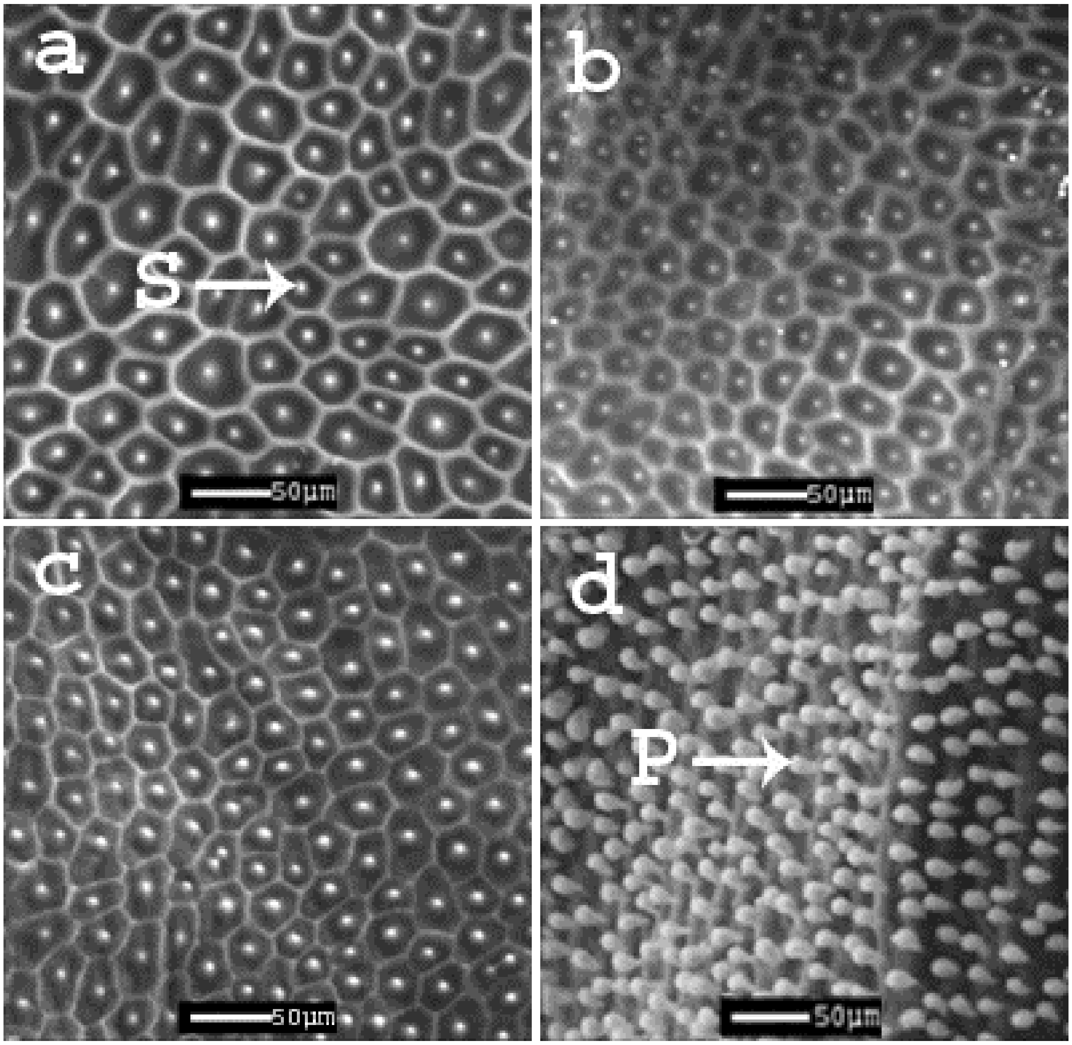

FIG. 1. Environmental scanning electron micrographs of *Carex* section *Glaucescentes*. Achene epidermal cells: a. *C. glaucescens*, S. Central silica body. b. *C. joorii*. c. *C. verrucosa*. Perigynia surface: d. *C. glaucescens*, P. Clavate papillae.

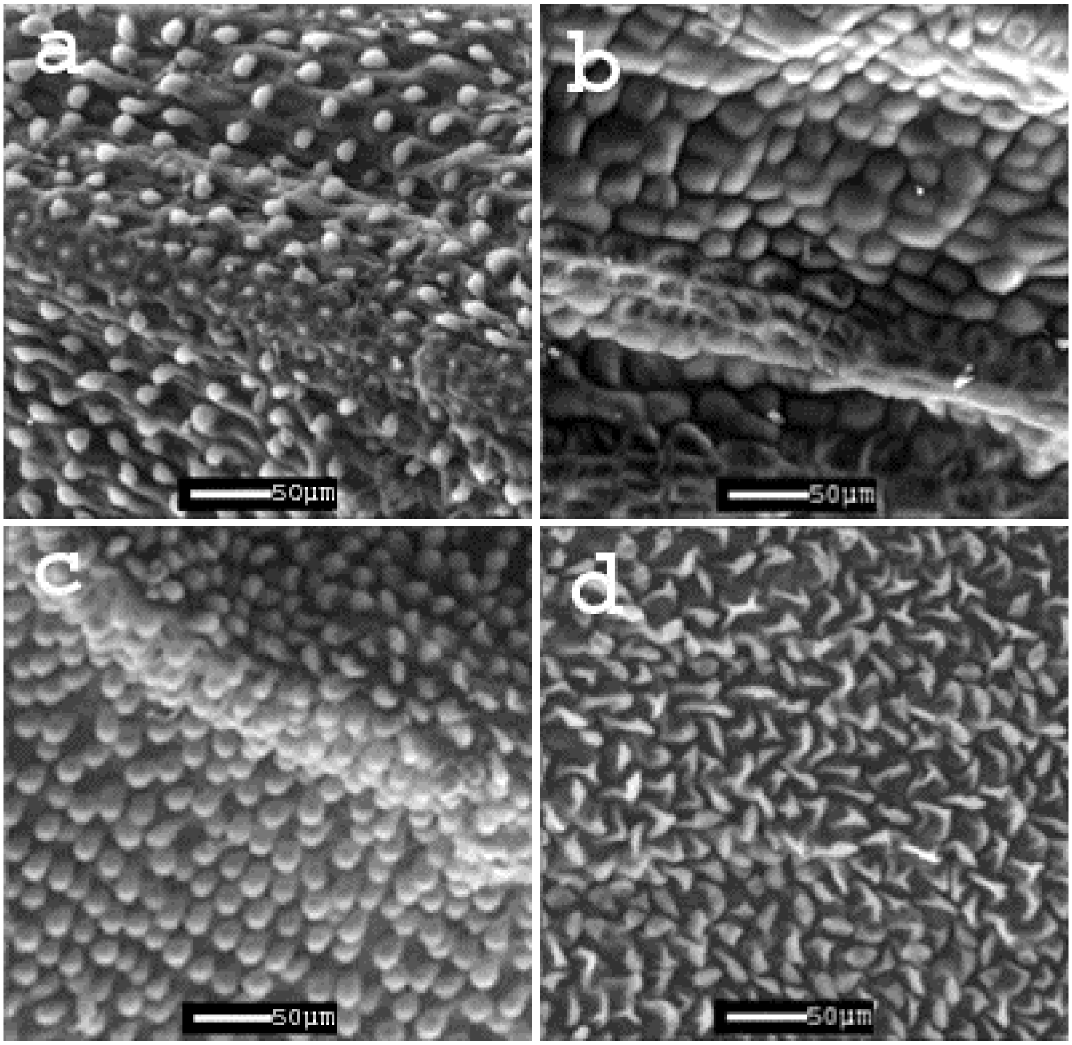

FIG. 2. Environmental scanning electron micrographs of *Carex* section *Glaucescentes*. Perigynia surface: a. *C. joorii* reduced papillae. b. *C. joorii* papillae rounded to absent with concave reticulate cells. c. *C. verrucosa* clavate papillae. d. *C. verrucosa* longitudinally troughed or compressed papillae.

with clavate papillae. The papillae on *C. glaucescens* and *C. verrucosa* are clavate to terete and sometimes compressed or troughed. Compressed papillae may be a true character state or a result of the vacuum used in ESEM. Perigynia texture is not a consistent taxonomic character to separate these taxa.

<u>Data Analysis</u>

Univariate Analysis

Descriptive statistics for the continuous variables used in PCA for *C. glaucescens*, *C. joorii* and *C. verrucosa* are in Tables 7-9, respectively. The mean flowering dates for *C. verrucosa* are approximately two months earlier than *C. glaucescens* and *C. joorii*. Measurement ranges overlap for most characters, however each character mean is different for at least one taxon.

Multivariate Analysis of Borrowed Specimens

The PCA of 26 characters and all three taxa explains 48.06 percent of the total variation among OTU's (Table 10). This percent total variation explained was low, initiating steps to increase variation explained by decreasing characters used. The PCA depicts three groups, which were aligned with the accepted taxa (Fig. 3). Because the PCA depicted 3 groups, the OTU's were A Priori labeled by taxon. *Carex joorii* is rather distinctly separated from *C. glaucescens* and *C. verrucosa*. However, it is retained in the following analyses because it is suspected to hybridize with *C. verrucosa* and possibly *C. glaucescens*.

In order to create a PCA with greater percent variation explained, PCA's of taxon pairings were used to decrease the number of characters. The following taxon pairing PCA's, explain a low percent of the total variation between OTU's. The percent

TABLE 10. Eigenvector coefficients from the PCA of 26 characters used to clarify groups for a priori taxon labeling. Percent trace and cumulative variation explained for the first three principal components are presented.

CHARACTER[a]	PC 1	PC 2	PC 3
FD	0.114	0.471	0.116
IL	-0.753	-0.203	0.049
HP	-0.470	-0.074	-0.535
SLS	-0.761	0.250	-0.109
SLP	-0.209	-0.021	-0.275
SLSC	-0.419	-0.121	-0.239
SWSC	0.098	0.002	-0.034
SWSP	-0.071	-0.302	-0.501
PLLP	-0.510	0.661	-0.008
PLUP	-0.157	0.715	-0.393
PLLS	-0.778	0.202	-0.106
PLUS	-0.545	0.366	-0.208
PLC	-0.292	-0.313	-0.523
PWC	0.056	-0.232	0.042
PLCW	-0.107	-0.064	-0.541
LLS	-0.822	0.105	0.084
LLP	-0.638	0.374	0.140
GL	-0.302	0.021	0.355
GLBK	-0.312	0.131	0.817
GW	-0.334	-0.479	0.559
GWB	-0.096	-0.725	-0.336
GLB	-0.115	-0.723	-0.356
LWP	-0.458	-0.535	-0.198
ALWOS	-0.229	-0.005	0.259
AW	-0.372	-0.675	0.373
GNN	-0.344	-0.455	0.681
% TRACE	18.560	15.812	13.692
COMBINED % TRACE			48.064

a Character codes are in Table 2.

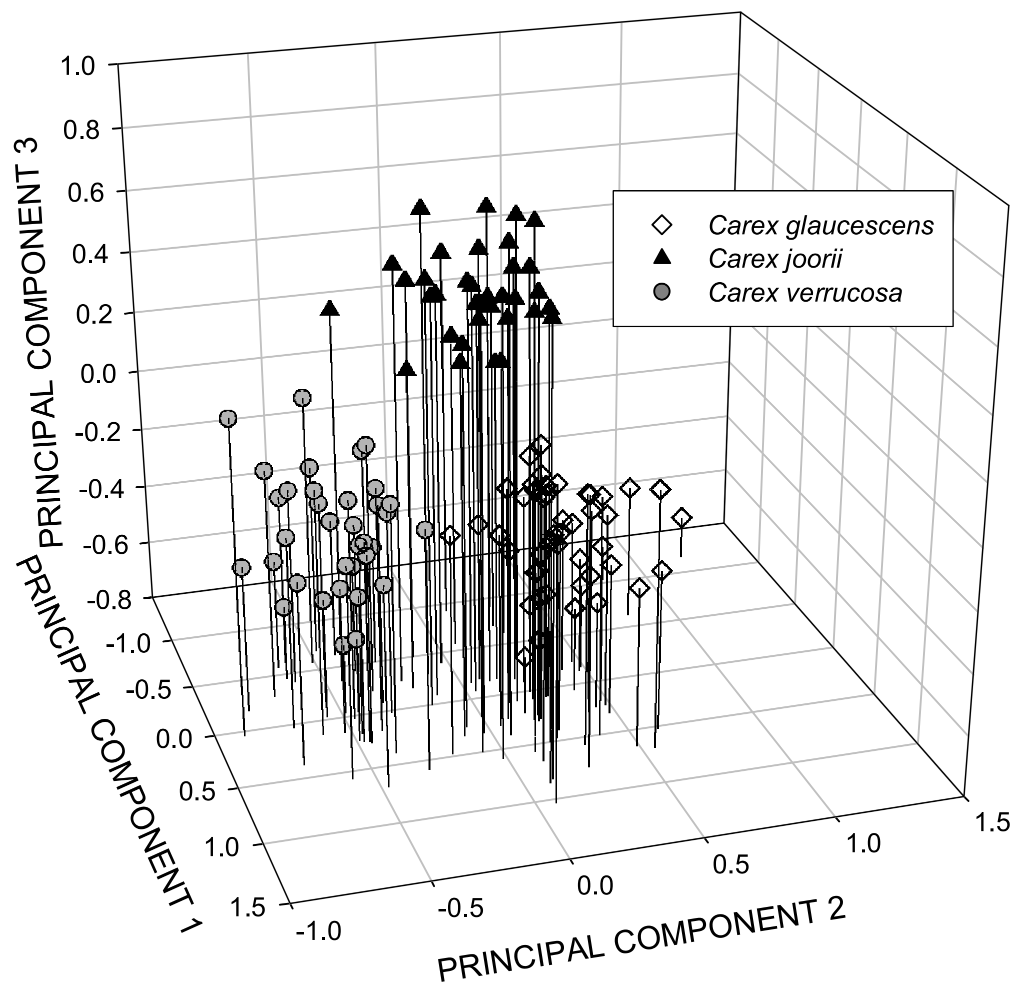

FIG. 3. PCA on *Carex glaucescens*, *C. joorii* and *C. verrucosa*, using 26 characters. The first three principal components are plotted.

of total variation explained is low because many of the 26 characters used are not taxonomically important. The use of taxon pairing PCA's enabled the selection of taxonomically important characters for a subsequent PCA.

Eigenvector coefficients of selected characters from the first taxon pairing PCA of 26 characters from *C. glaucescens* and *C. joorii* are length of lowermost lateral spike (LLS) (0.848), inflorescence length (IL) (0.813) and length of terminal spike (SLS) (0.806) (Table 11). *Carex glaucescens* and *C. joorii* are clearly separated by the first two principal components (Fig. 4). The first three principal components explain 49.071 percent of the total variation among OTU's. This PCA is an unacceptable representation of the OTU's because it explains a low amount of variation between taxa.

The second taxon pairing PCA contained 26 characters from *C. glaucescens* and *C. verrucosa*. Eigenvector coefficients of selected characters from the second PCA taxon pairing are widest point of achene (AW) (0.890), number of veins on perigynia faces (GNN) (0.844), length of perigynia stipitate base (GLB) (0.839) and width of perigynia stipitate base (GWB) (0.816) (Table 12). The first three principal components explain 49.064 percent of the total variation among OTU's. *Carex glaucescens* and *C. verrucosa* are separated by the first two principal components in Figure 5. This PCA is an unacceptable representation of the OTU's because it explains a low amount of variation between taxa.

The third taxon pairing PCA contained 26 characters of *C. joorii* and *C. verrucosa.* Eigenvector coefficients of selected characters from the third PCA taxon pairing are length of perigynia beak (GLBK) (0.841), length of second lowermost lateral pistillate spike peduncle (PLLP) (0.802), length of perigynia stipitate base (GLB) (0.690)

TABLE 11. Eigenvector coefficients from the taxon pairing PCA of 26 characters from *Carex glaucescens* and *C. joorii*. Percent trace and cumulative variation explained for the first three principal components are presented.

CHARACTER[a]	PC 1	PC 2	PC 3
FD	0.046	0.053	0.419
IL*	-0.813	0.159	0.061
HP	-0.422	-0.577	-0.037
SLS*	-0.806	-0.201	-0.092
SLP	-0.136	-0.323	0.070
SLSC	-0.488	-0.206	-0.339
SWSC	0.257	0.001	0.409
SWSP	-0.269	-0.581	-0.383
PLLP	-0.656	-0.261	0.504
PLUP	-0.245	-0.715	0.336
PLLS	-0.790	-0.133	-0.136
PLUS	-0.529	-0.369	-0.162
PLC	-0.358	-0.443	0.236
PWC	0.090	0.222	0.243
PLCW	-0.127	-0.544	0.480
LLS*	-0.848	0.076	-0.029
LLP	-0.700	0.016	0.445
GL	-0.379	0.304	-0.137
GLBK	-0.395	0.832	0.121
GW	-0.309	0.742	0.171
GWB	0.068	-0.196	-0.258
GLB	0.174	-0.332	-0.257
LWP	-0.535	0.054	-0.401
ALWOS	-0.360	0.225	-0.319
AW	-0.381	0.723	0.008
GNN	-0.305	0.878	0.028
% TRACE	22.020	19.221	7.830
COMBINED % TRACE			49.071

a Character codes are in Table 2.

* Characters selected for final PCA.

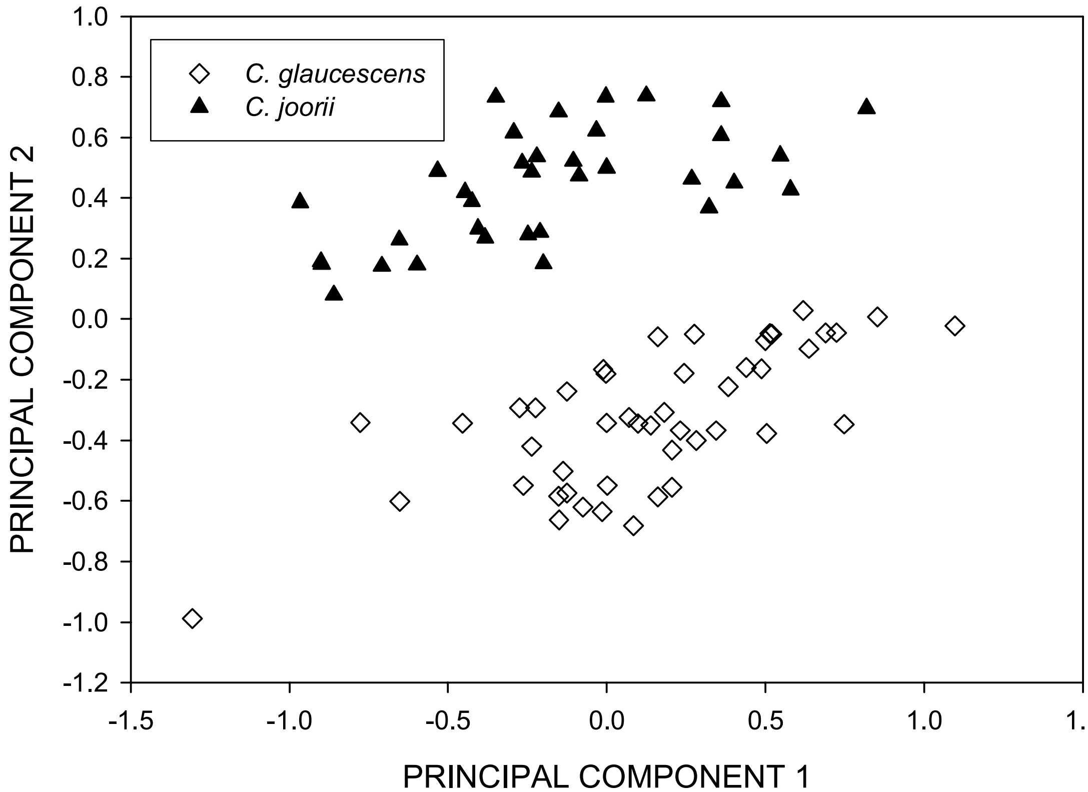

FIG. 4. PCA on *Carex glaucescens* and *C. joorii* in a taxon pairing with 26 characters. The first and second principal components are plotted.

TABLE 12. Eigenvector coefficients from the taxon pairing PCA of 26 characters from *Carex glaucescens* and *C. verrucosa*. Percent trace and cumulative variation explained for the first three principal components are presented.

CHARACTER[a]	PC 1	PC 2	PC 3
FD	0.521	0.002	0.646
IL	-0.540	-0.586	-0.320
HP	-0.268	-0.585	0.155
SLS	-0.047	-0.782	-0.160
SLP	-0.107	-0.267	-0.103
SLSC	-0.254	-0.354	0.259
SWSC	0.030	0.049	-0.136
SWSP	-0.285	0.002	0.434
PLLP	0.442	-0.692	0.066
PLUP	0.628	-0.543	0.077
PLLS	-0.105	-0.779	-0.195
PLUS	0.179	-0.660	-0.065
PLC	-0.426	-0.221	0.698
PWC	-0.191	0.116	0.048
PLCW	-0.121	-0.184	0.696
LLS	-0.247	-0.734	-0.163
LLP	0.077	-0.685	-0.111
GL	-0.126	-0.186	0.450
GLBK	-0.021	-0.168	0.064
GW	-0.791	0.122	0.052
GWB*	-0.816	0.120	-0.125
GLB*	-0.839	0.030	-0.036
LWP	-0.668	-0.159	-0.088
ALWOS	-0.078	-0.154	0.575
AW*	-0.890	0.003	0.078
GNN*	-0.844	0.109	-0.004
% TRACE	21.907	17.577	9.579
COMBINED % TRACE			49.064

a Character codes are in Table 2.

* Characters selected for final PCA.

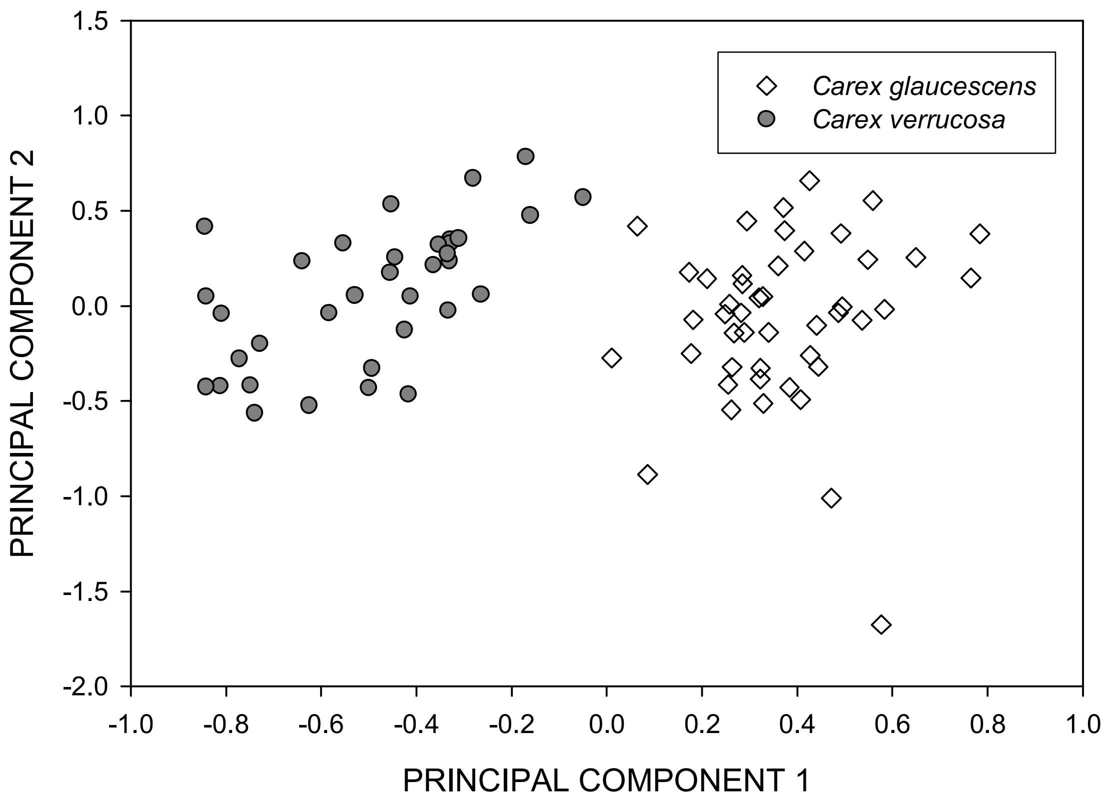

FIG. 5. PCA on *Carex glaucescens* and *C. verrucosa* in a taxon pairing with 26 characters. The first and second principal components are plotted.

and length of lowermost lateral spike peduncle (LLP) (0.678) (Table 13). The first three principal components explain 50.339 percent of the total variation among the OTU's. *Carex joorii* and *C. verrucosa* are separated by the first two principal components (Fig. 6). Characters selected from the taxon pairings were used in a PCA of all three taxa. The taxon pairing PCA's have low percent variation explained among the OTU's (Table 14). Each pairing only marginally increased percent variation explained because the taxon excluded from each pairing is closely related to the two remaining taxa. The large number of taxonomically non-important characters is also responsible for decreased percent variation.

Finally, a PCA was performed on the data matrix of 117 OTU's using 10 characters selected from taxon pairing PCA's (Table 14). The ten characters selected from the three pairings are LLS, IL, SLS, AW, GNN, GLB, GWB, GLBK, PLLP, LLP. The first three principal components explained 76.77 percent of the variation among OTU's. Reducing the data matrix to 10 characters greatly increased the percent variation explained among OTU's. A three dimensional representation of the PCA shows three groups of taxa (Fig. 7). The groups correspond with the a priori labeling of OTU's with *C. glaucescens*, *C. joorii* and *C. verrucosa*. OTU's of the same taxon are grouped more closely to each other and further from other taxa than when 26 characters were used. *Carex glaucescens* and *C. joorii* are separated by principal components 1 and 3 (Fig. 8). *Carex glaucescens* and *C. verrucosa* are separated by principal components 1 and 2 (Fig. 9). *Carex joorii* and *C. verrucosa* are separated by principal components 1 and 3 (Fig. 10). The OTU's from the PCA of 10 characters were labeled by state abbreviation (e.g. TX and LA). Scatter plots of principal components 1

TABLE 13. Eigenvector coefficients from the taxon pairing PCA of 26 characters from *Carex joorii* and *C. verrucosa*. Percent trace and cumulative variation explained for the first three principal components are presented.

CHARACTER[a]	PC 1	PC 2	PC 3
FD	0.363	0.275	0.570
IL	0.239	-0.661	-0.337
HP	-0.224	-0.728	0.324
SLS	0.498	-0.614	-0.060
SLP	-0.118	-0.403	-0.014
SLSC	-0.032	-0.457	0.315
SWSC	-0.039	-0.233	0.316
SWSP	-0.505	-0.241	0.234
PLLP*	0.802	-0.181	-0.159
PLUP	0.595	-0.182	0.013
PLLS	0.469	-0.679	-0.140
PLUS	0.481	-0.569	0.106
PLC	-0.428	-0.486	0.439
PWC	-0.144	0.088	0.170
PLCW	-0.360	-0.288	0.337
LLS	0.569	-0.617	-0.121
LLP*	0.678	-0.323	-0.286
GL	0.377	0.011	0.593
GLBK*	0.841	0.273	0.137
GW	0.344	-0.043	0.260
GWB	-0.676	-0.433	-0.188
GLB*	-0.690	-0.443	-0.075
LWP	-0.326	-0.633	-0.040
ALWOS	0.232	0.112	0.737
AW	-0.161	-0.184	0.632
GNN	0.655	0.068	0.238
% TRACE	22.4625	17.2264	10.6498
COMBINED % TRACE			50.339

a Character codes are in Table 2.
* Characters selected for final PCA.

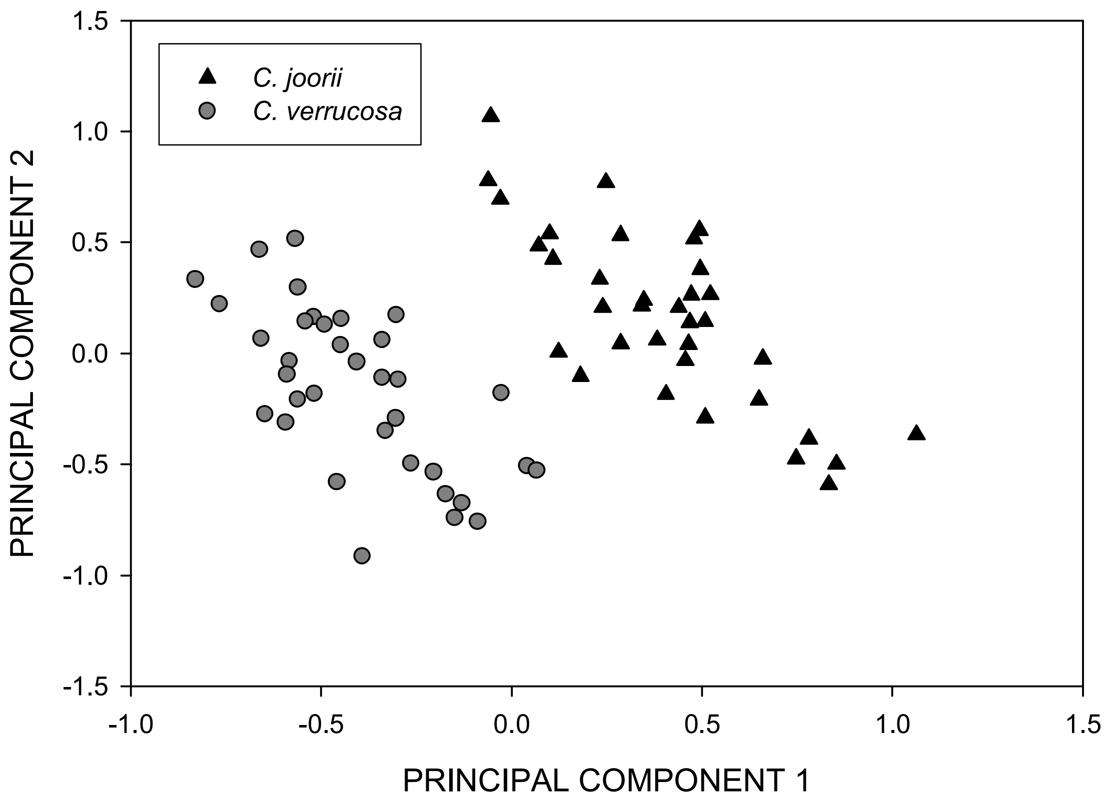

FIG. 6. PCA on *Carex joorii* and *C. verrucosa* in a taxon pairing with 26 characters. The first and second principal components are plotted.

TABLE 14. Eigenvector coefficients from the PCA of 10 characters. Percent trace and cumulative variation explained for the first three principal components are presented.

CHARACTER[a]	PC 1	PC 2	PC 3
IL	0.715	0.422	0.312
SLS	0.694	-0.069	0.327
PLLP	0.695	-0.500	0.275
LLS	0.763	0.128	0.118
LLP	0.824	-0.166	0.253
GLBK	0.589	0.005	-0.701
GWB	-0.198	0.767	0.437
GLB	-0.185	0.777	0.434
AW	0.257	0.742	-0.368
GNN	0.427	0.551	-0.620
% TRACE	34.057	25.221	17.491
COMBINED % TRACE			76.770

a Character codes are in Table 2.

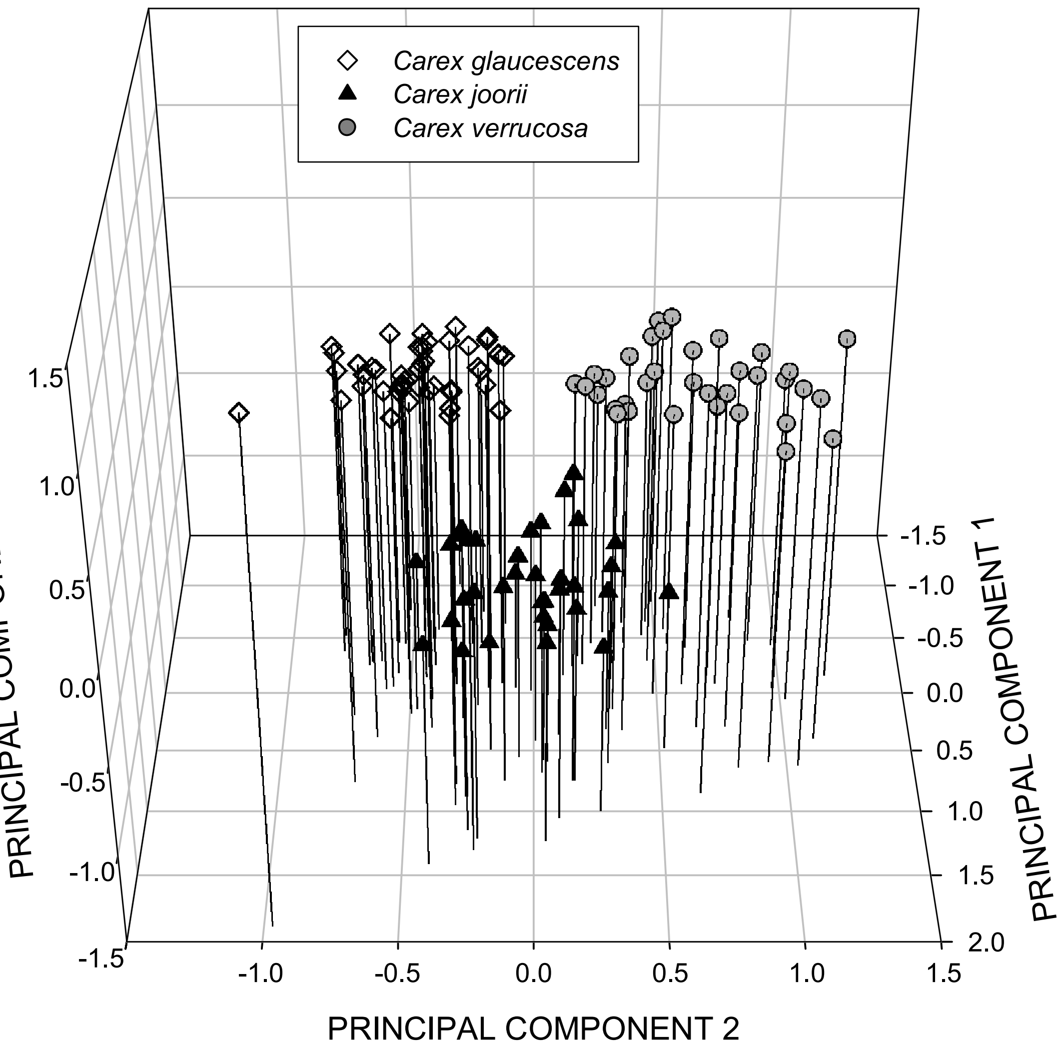

FIG. 7. PCA for *Carex glaucescens*, *C. joorii* and *C. verrucosa* with a reduced data matrix of 10 characters. The first three principal components are plotted.

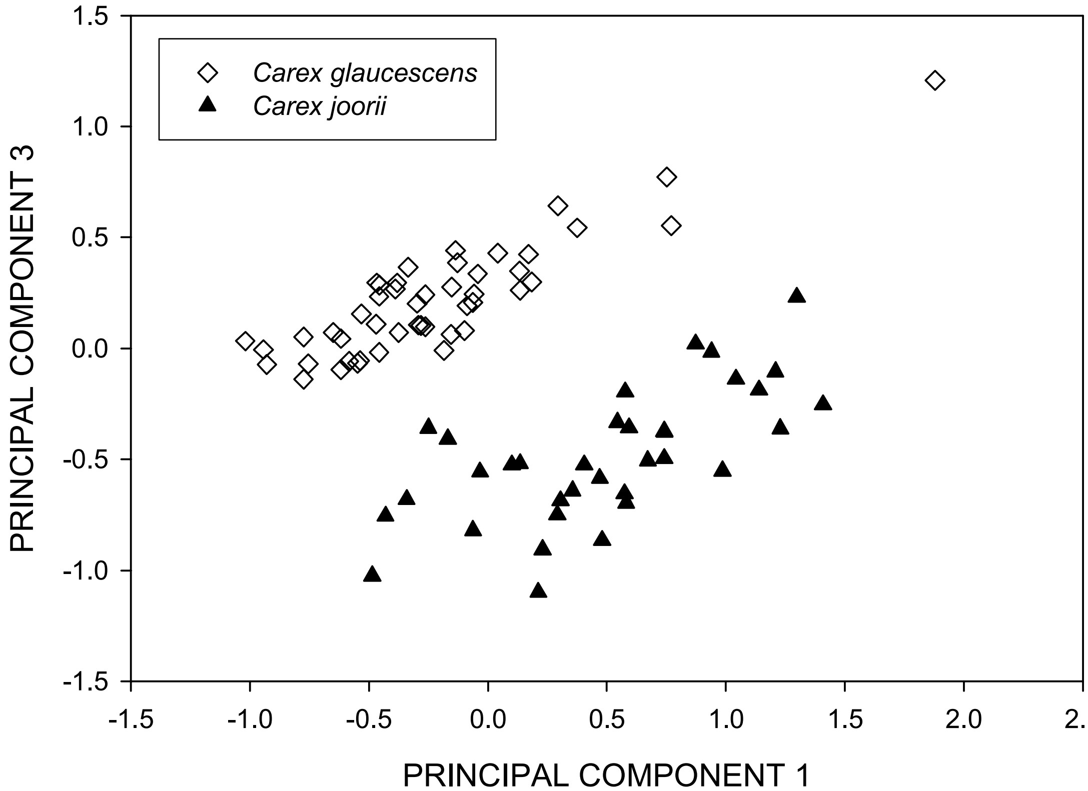

FIG. 8. The first and third principal components are plotted for *Carex glaucescens* and *C. joorii* from a PCA of *C. glaucescens*, *C. joorii* and *C. verrucosa* on a reduced data matrix of 10 characters.

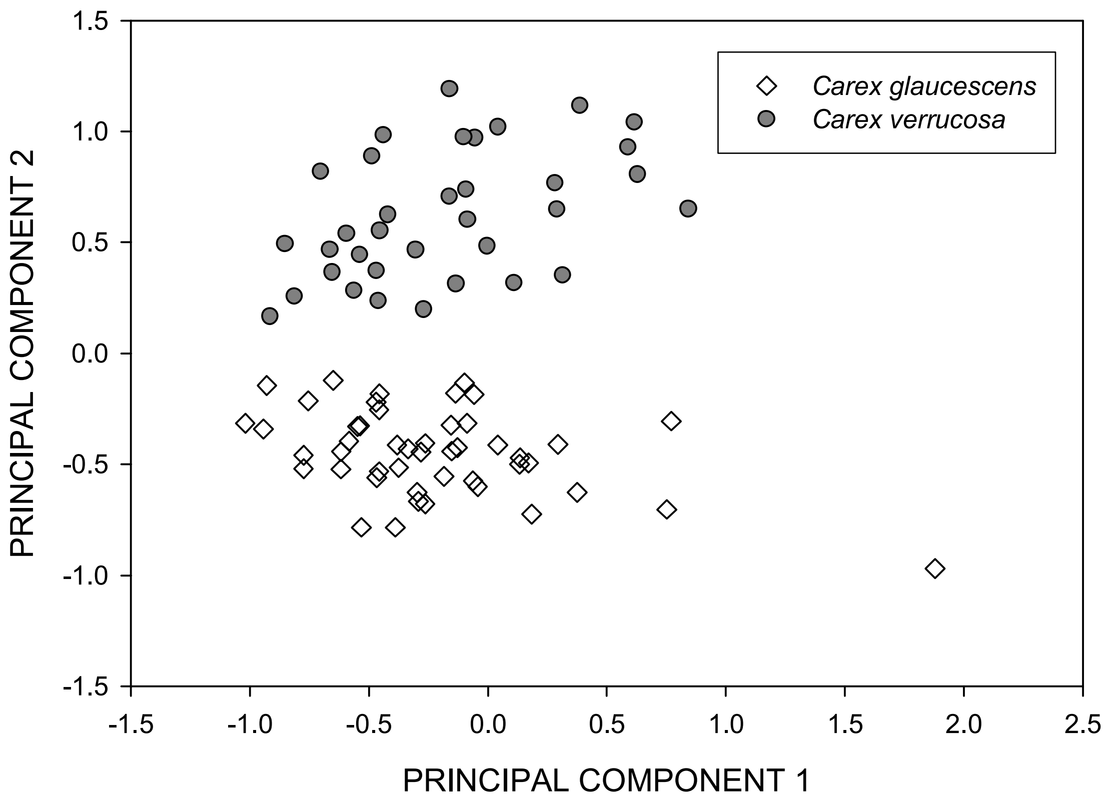

FIG. 9. The first and second principal components are plotted for *Carex glaucescens* and *C. verrucosa* from a PCA of *C. glaucescens*, *C. joorii* and *C. verrucosa* on a reduced data matrix of 10 characters.

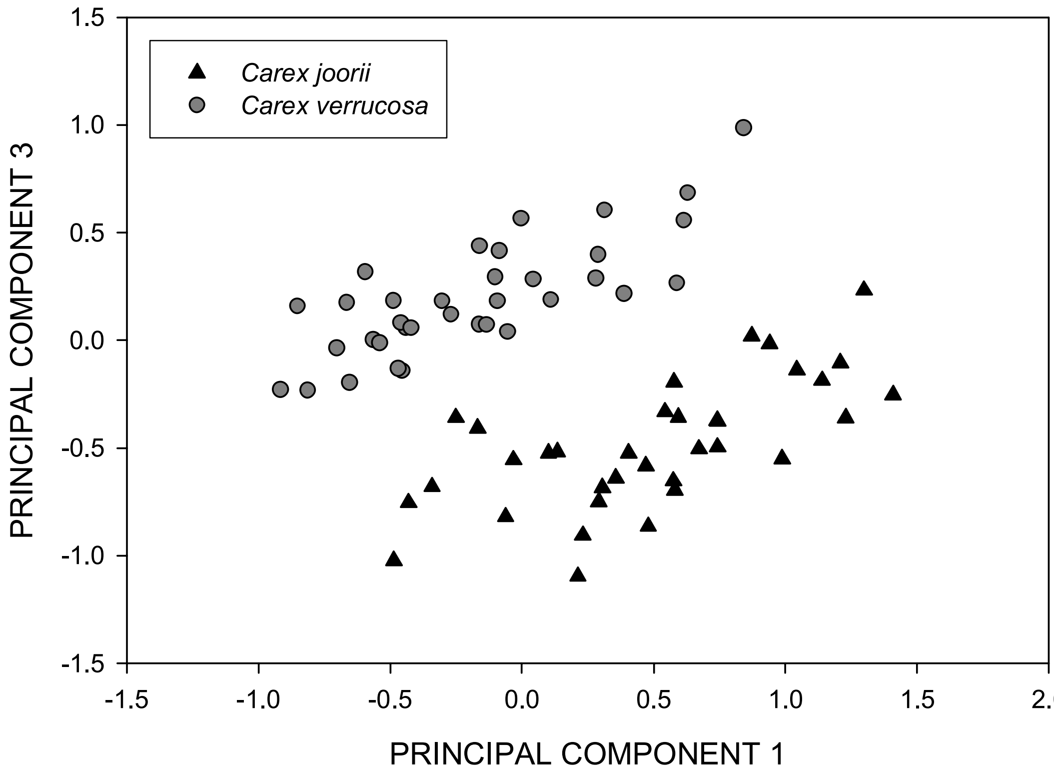

FIG. 10. The first and third principal components are plotted for *Carex joorii* and *C. verrucosa* from a PCA for *C. glaucescens*, *C. joorii* and *C. verrucosa* on a reduced data matrix of 10 characters.

and 2 were graphed separately for each taxon (Figs. 11-13). The scatter plots were evaluated for clustering of OTU's by single and multiple state groupings. There was no distinct clustering by states for *C. glaucescens*, *C. joorii* or *C. verrucosa*, suggesting that there are not distinct morphological differences based on longitude, latitude or elevation within each taxon.

Multivariate Analysis of Collected Populations Including Suspected Hybrids

The same three separate clusters were found in the combined PCA of borrowed specimens and personal collections. Eigenvector coefficients greater than 0.7 from principal component 1 are LLP (0.729) and LLS (0.719) (Table 15). Characters with eigenvector coefficients greater than 0.7 from the second principal component are GLB (0.756), GWB (0.749) and AW (0.743). The first three principal components explain about 74 percent of the total variation among the OTU's. The percent variation is reduced by about 2.6 percent, which is likely explained because the suspected hybrid taxa were included. These specimens were infertile and therefore achene width was not measured. *Carex glaucescens, C. joorii* and *C. verrucosa* are depicted as separate clusters by the first three principal components (Fig. 14). Personal collection specimens align with borrowed specimens of the same taxon. This reaffirms the lack of phenotypic variation based on geographic locality.

The suspected hybrid specimens are positioned at the margin of *C. joorii* and *C. verrucosa* PCA graphical data display (Fig. 14). The three suspected hybrid specimens are infertile and did not produce achenes in the year of study. Morphologically, the specimens mostly resemble *C. joorii* with squarrose, inflated and prominently veined perigynia and tapered pistillate scales. They resemble *C. verrucosa* by flowering in

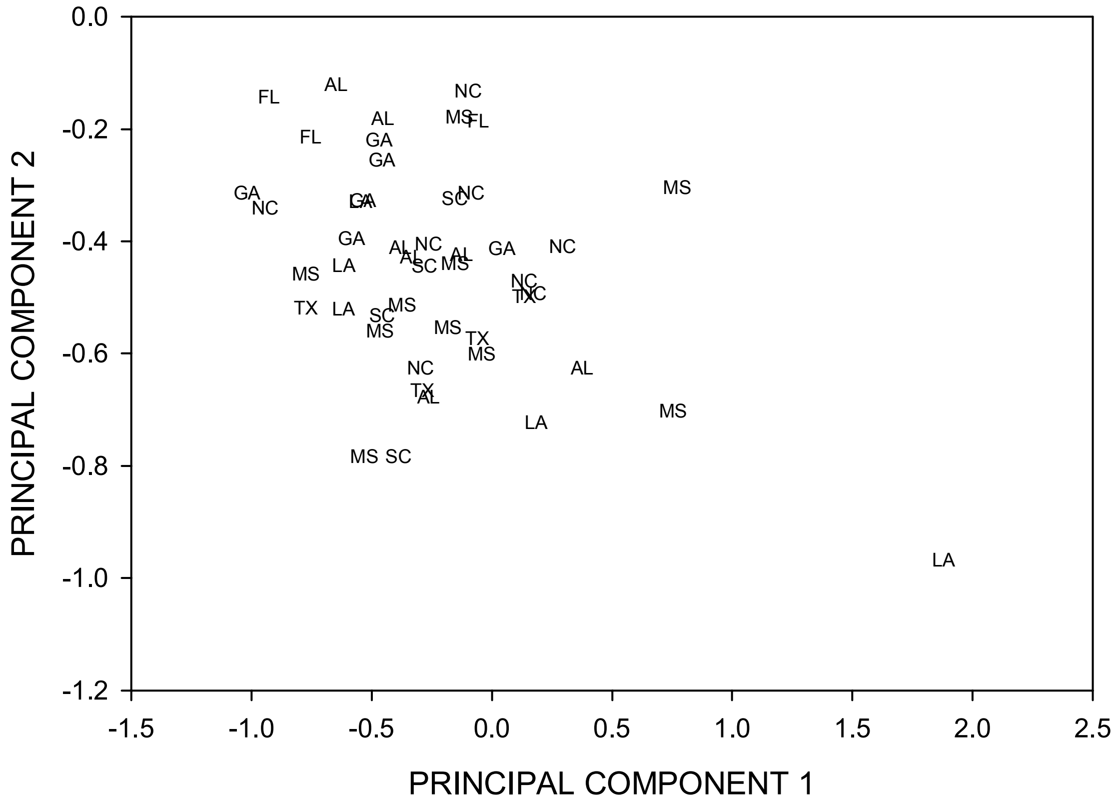

FIG. 11. The first and second principal components are plotted for *Carex glaucescens*. OTU's are labeled by state abbreviation, to aid in the examination of geographic phenotypic variation.

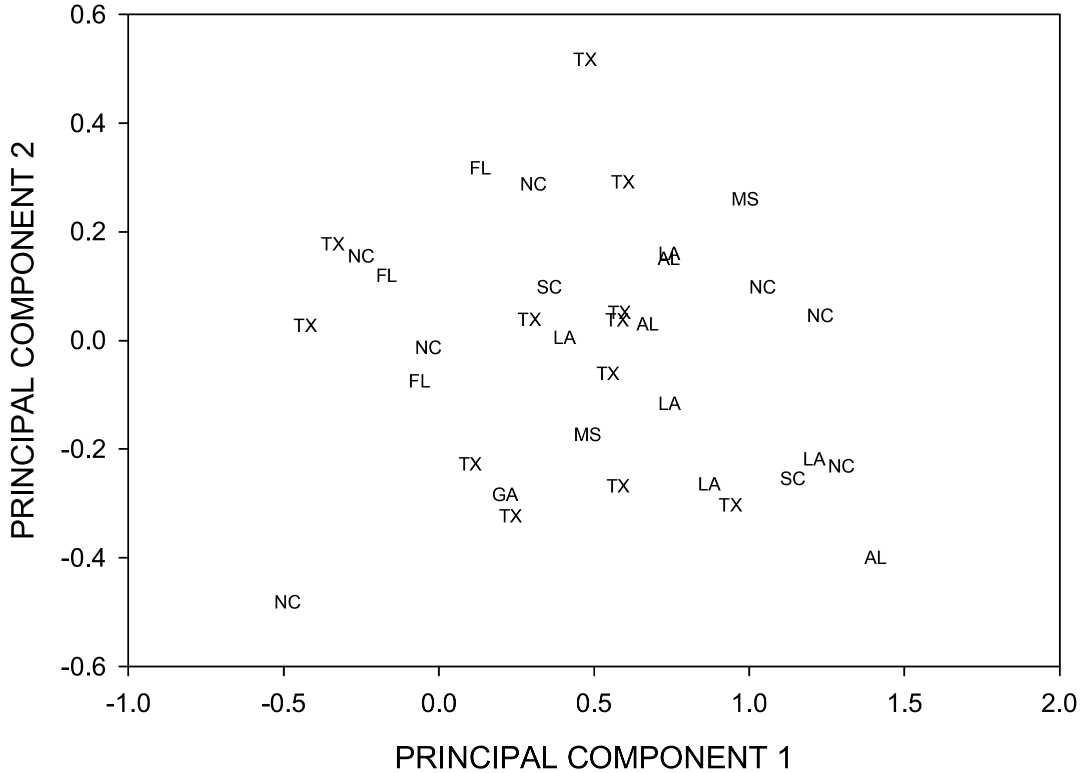

FIG. 12. The first and second principal components are plotted for *Carex joorii*. OTU's are labeled by state abbreviation to aid in the examination of geographic phenotypic variation.

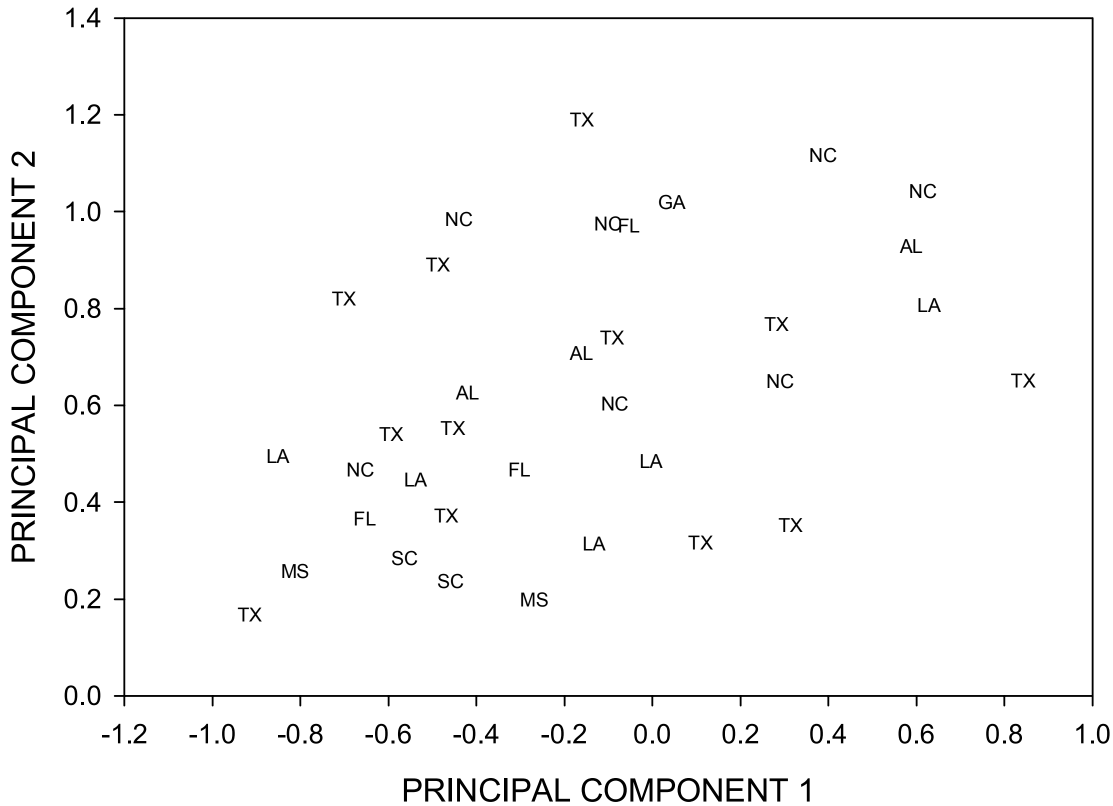

FIG. 13. The first and second principal components are plotted for *Carex verrucosa*. OTU's are labeled by state abbreviation to aid in the examination of geographic phenotypic variation.

TABLE 15. Eigenvector coefficients from the PCA of 10 characters from borrowed herbarium specimens and personal collections. Percent trace and cumulative variation explained for the first three principal components are presented.

CHARACTER[a]	PC 1	PC 2	PC 3
IL	0.674	0.393	0.369
SLS	0.653	0.064	0.372
PLLP	0.575	-0.629	0.306
LLS	0.719	0.167	0.118
LLP	0.729	-0.370	0.271
GLBK	0.625	-0.019	-0.667
GWB	-0.180	0.749	0.416
GLB	-0.165	0.756	0.416
AW	0.330	0.743	-0.301
GNN	0.465	0.497	-0.623
% TRACE	30.338	26.503	17.241
COMBINED % TRACE			74.082

a Character codes are in Table 2.

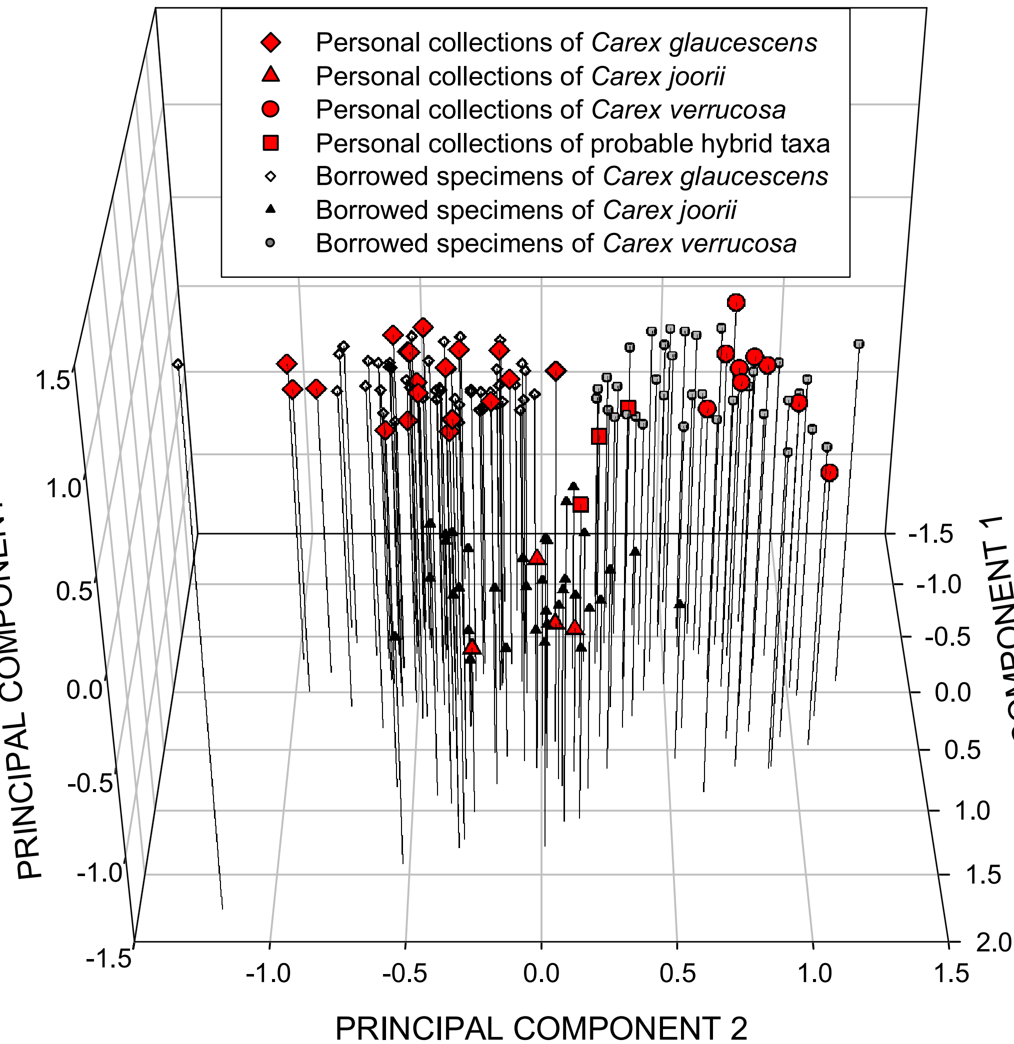

FIG. 14. The first three principal components are plotted for a PCA of borrowed herbarium specimens and personal collections, including possible hybrid taxa.

early spring, having a terminal spike of mostly pistillate spikelets and reduced peduncles.

Another possible hybrid is from *C. glaucescens* X *C. joorii*. They are suspected to produce a fertile hybrid, resembling *C. joorii*, with clavate papillose perigynia (Standley 2002). The clavate papillose specimens do not cluster separately from *C. joorii* specimens with rounded and horizontally sunken papillae. Hybridization may be a possible explanation for the clavate papillae on *C. joorii*; however this is a not consistent explanation. Many *C. joorii* specimens have clavate papillae on the beak and rounded and horizontally sunken papillae on the perigynia body. From the total borrowed herbarium specimens, there are five specimens from Arkansas with clavate papillae on the perigynia body (Table 16). It is difficult to accept these *C. joorii* specimens as hybrids because both *C. glaucescens* and *C. verrucosa* do not occur in Arkansas.

Multivariate Analysis with Carex joorii Holotype Specimen

The first three principal components for this PCA included the *C. joorii* holotype specimen explained 75.37 percent of the total variation among OTU's (Table 17). Percent total variation explained was marginally increased by adding the type specimen. The *C. joorii* type specimen corresponded to specimens labeled with the respective taxon (Fig. 18). No type specimen for *C. glaucescens* or *C. verrucosa* were located for measurement and analysis.

<u>Taxa Distributions</u>

Taxa in the section *Glaucescentes* have overlapping geographical distributions. *Carex glaucescens* is distributed in AL, FL, GA, LA, MD, MS, NC, SC, TN, TX and VA (Fig. 16). *Carex joorii* is distributed in AR, FL, GA, KY, LA, MD, MO, MS, NC, SC, TN, TX and VA (Fig. 17). *Carex verrucosa* is distributed in AL, FL, GA, LA, MS, NC, SC and

TABLE 16. Borrowed specimens of *Carex joorii* from Arkansas with clavate papillae.

HERBARIUM AND ACCESSION NUMBER		COLLECTOR	COLLECTOR NUMBER	STATE	COUNTY	COLLECTION DATE
MICH	—	Steve L. Orzell	2646	AR	BRADLEY	8 Aug 1985
MICH	—	Steve L. Orzell	3178	AR	CALHOUN	6 Oct 1985
NLU	92010	David Lawson	2071	AR	SEVIER	23 Jul 1974
NLU	287925	Sundell & Ethridge	7995	AR	BRADLEY	8 Oct 1987
SFRP	5327	A. Martin	344	AR	DREW	6 Sep 1978

TABLE 17. Eigenvector coefficients from the PCA of 10 characters from borrowed herbarium specimens including type specimens. Percent trace and cumulative variation explained for the first three principal components are presented.

CHARACTER[a]	PC 1	PC 2	PC 3
IL	0.729	0.418	0.281
SLS	0.696	-0.072	0.336
PLLP	0.706	-0.505	0.231
LLS	0.769	0.121	0.098
LLP	0.832	-0.175	0.202
GLBK	0.512	0.019	-0.709
GWB	-0.176	0.767	0.442
GLB	-0.155	0.780	0.416
AW	0.242	0.735	-0.358
GNN	0.406	0.549	-0.620
% TRACE	33.395	25.181	16.792
COMBINED % TRACE			75.368

a Character codes are in Table 2.

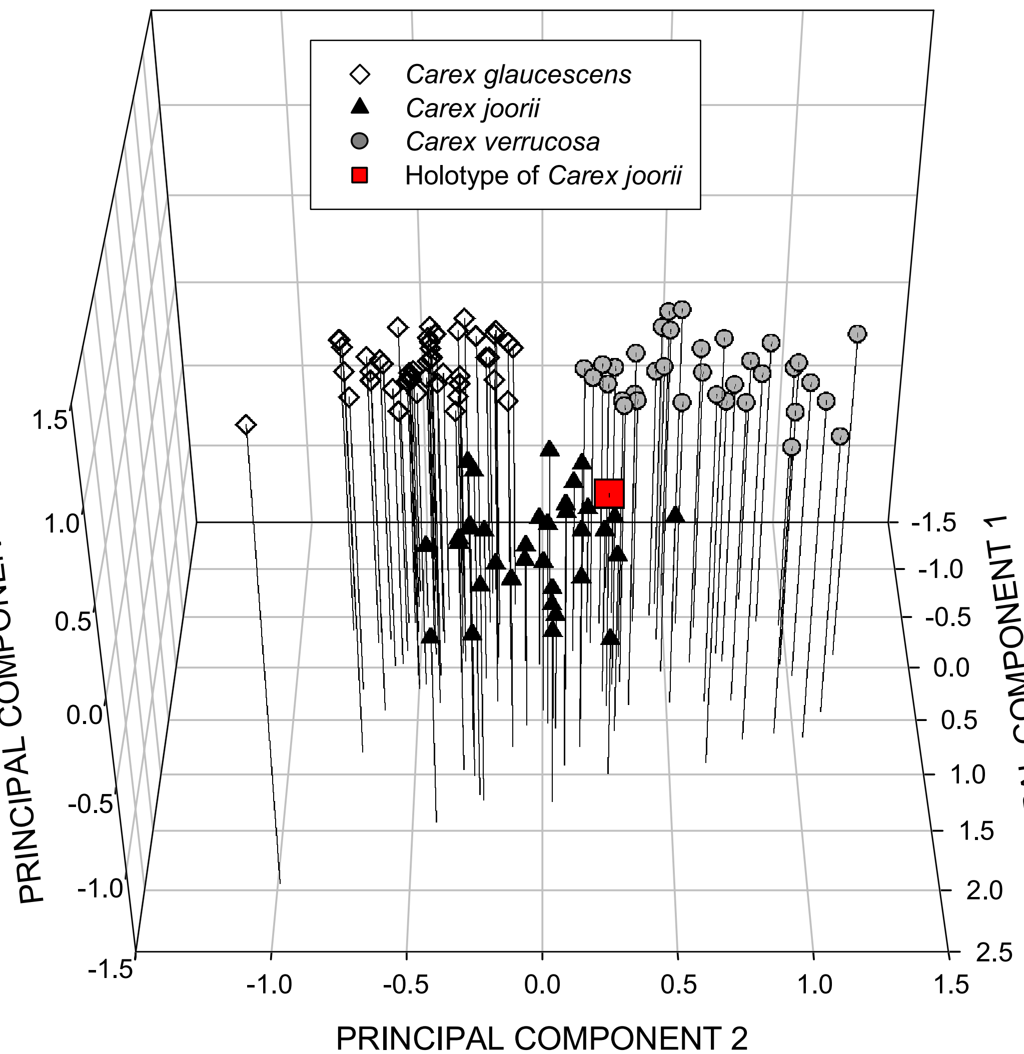

FIG. 15. The first three principal components are plotted for a PCA with 10 characters from *Carex glaucescens*, *C. joorii* and *C. verrucosa*, including the holotype of *C. joorii*.

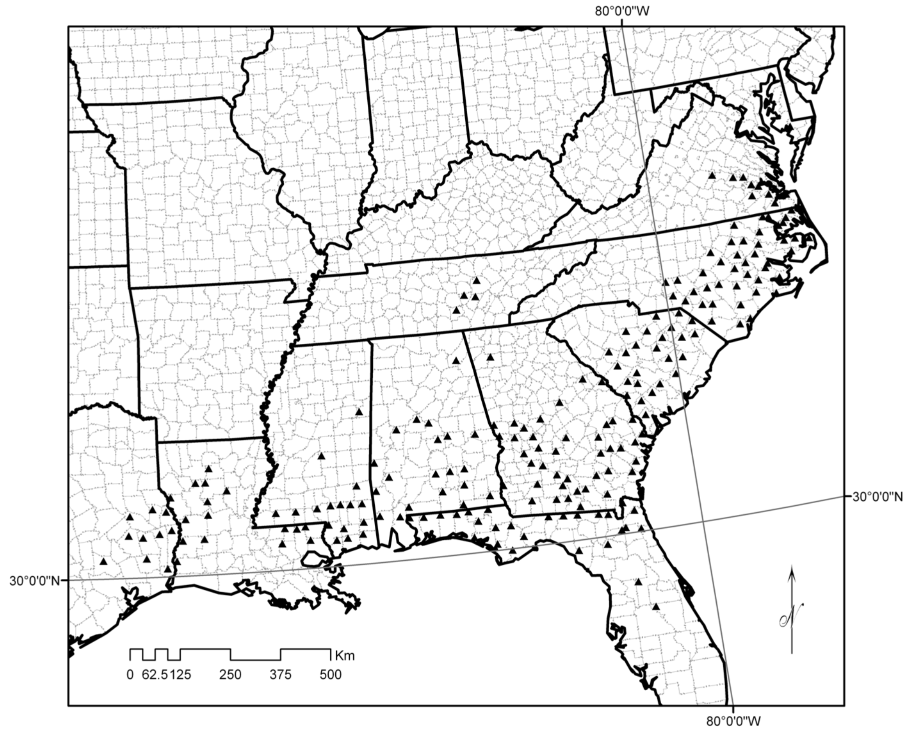

FIG. 16. County and state distribution map of *Carex glaucescens*, based on annotated herbarium specimens.

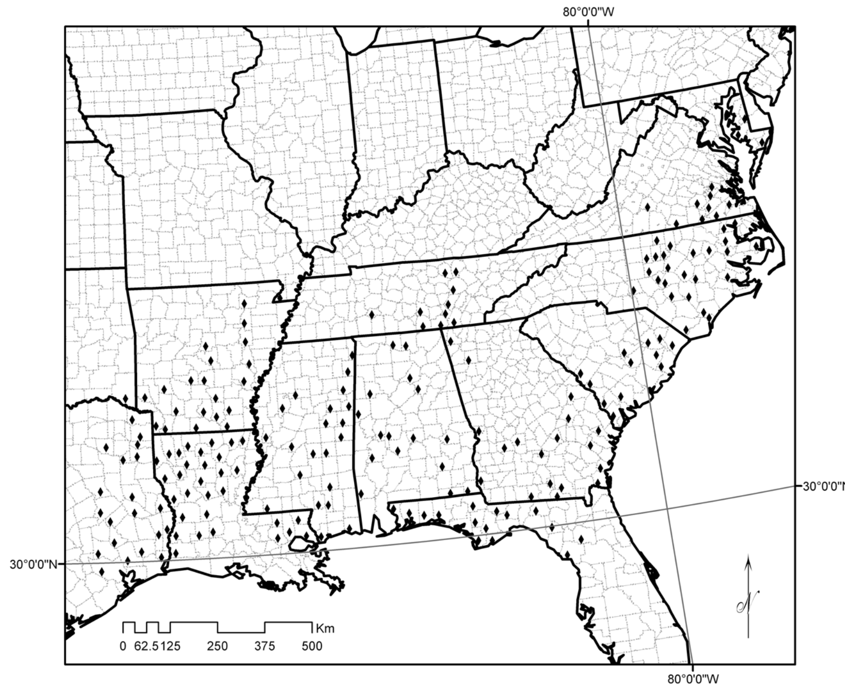

FIG. 17. County and state distribution map of *Carex joorii*, based on annotated herbarium specimens.

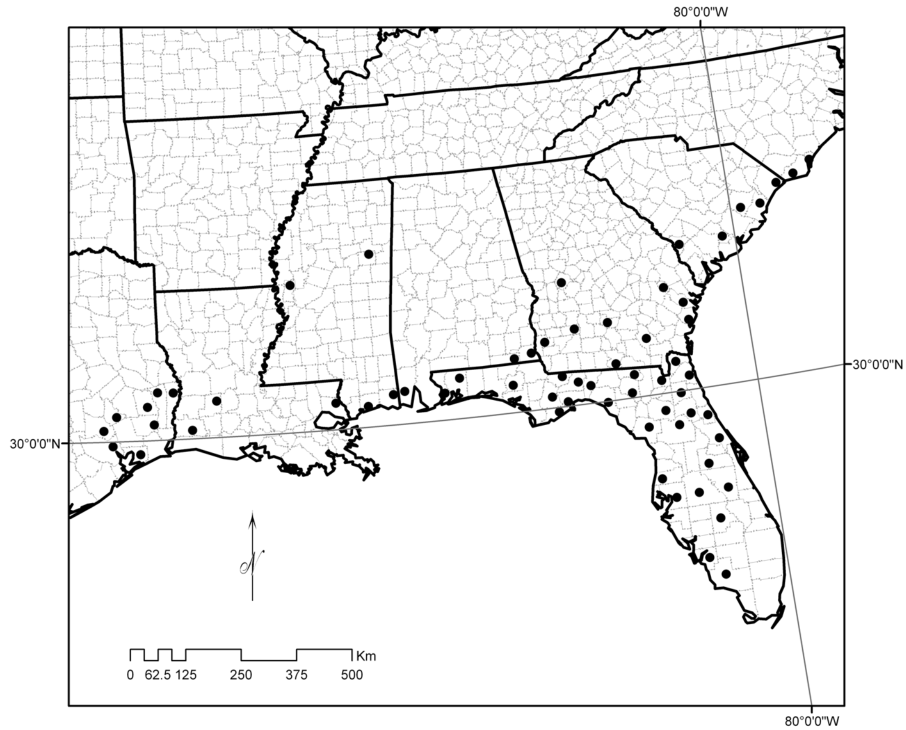

FIG. 18. County and state distribution map of *Carex verrucosa*, based on annotated herbarium specimens.

TX (Fig. 18). *Carex verrucosa* is limited to the southeastern coastal plain. *Carex glaucescens* extends north into the Piedmont and Appalachian plateaus. Distribution of *C. joorii* includes the southeastern coastal plain, Piedmont and Appalachian plateaus as well as the valley and ridge and the interior low plateau.

Results of data for allopatry and sympatry were taken from 16 populations of section *Glaucescentes* collected in Texas (Table 4). Even numbers of all taxa were not located, which may affect conclusions. *Carex glaucescens* and *C. joorii* were found to occur together without *C. verrucosa* twice and once (possibly twice) with *C. verrucosa*. Specimens found separately were *C. glaucescens* nine times, *C. joorii* once, and *C. verrucosa* three times (possibly twice). *Carex glaucescens* and *C. joorii* were the only two taxa to be found together without a third taxon present.

<u>Phenology</u>

Histograms for flowering dates by month are summarized by species in Figure 19. *Carex glaucescens* flowers from January to November, with most specimens collected during July, August and September and peaking in August. *Carex joorii* flowers from April to November, with most specimens collected during July to October and peaking during August. *Carex verrucosa* flowers from February to December with most specimens collected during March, April, May and June and peaking during April. Peak flowering times for *C. glaucescens* and *C. joorii* overlap in the summer, however the peak flowering time for *C. verrucosa* is in the spring. Most specimens of *C. verrucosa* are reproductively isolated from *C. glaucescens* and *C. joorii* by flowering time.

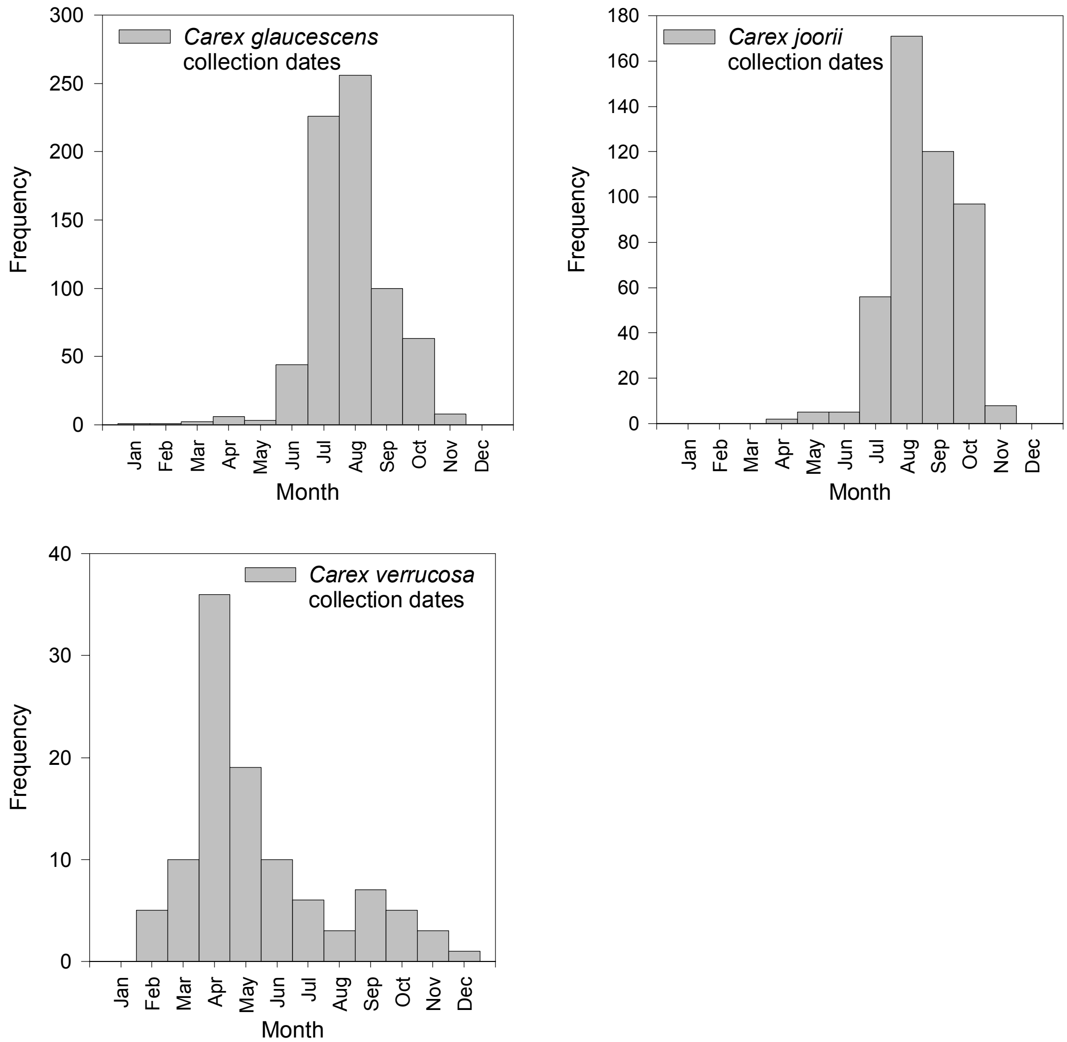

FIG. 19. Histogram of *Carex glaucescens*, *C. joorii* and *C. verrucosa* collection dates by month.

Taxonomy

Type Specimens

The *C. joorii* holotype is deposited at L. H. Bailey Hortorium Herbarium (BH). Type specimen images are in Appendix A. Holotype specimens for *C. glaucescens* and *C. verrucosa* were not located in herbaria or literature.

During the early nineteenth century it was typical not to designate a type, but to have one or two specimens on which to base descriptions. Two possibilities for typification of *C. verrucosa* were located in the literature and herbaria. First, Mackenzie (1935) noted a scrap of *C. verrucosa* as received from Muhlenberg and preserved in the Torrey Herbarium. This specimen, deposited at NY, consists merely of immature perigynia in a fragment packet. Comparisons of writing on the fragment packet label, by the author, with samples of Muhlenberg's handwriting do not appear to match. Regardless of handwriting on the packet, the specimen may still be Muhlenberg material labeled by another individual. Second, Smith (1962), while cataloging and researching Muhlenberg specimens at PH, located an Elliott specimen (an inflorescence) labeled in Muhlenberg's handwriting "215 *Carex verrucosa* ns". It was common for an author of a new species to write on labels the scientific name followed by species novum (ns, n.s., n. sp., sp. nov.). Considering these two specimens for type designation, with the conclusion that they were both examined by Muhlenberg and the determination that they are *C. verrucosa* material, it would be more prudent to accept Elliott 215 (PH) as the type specimen because of "ns" on the label and it is a more complete specimen. Further examination of correspondence between Muhlenberg and Elliott along with recommendations in the ICBN, will exclude these 2 specimens from typification.

Examination of correspondence housed at the Cambridge Harvard University Herbarium (GH) from Muhlenberg to Elliott added more information to Elliott 215 (PH). On 2 July 1810, Muhlenberg wrote a letter replying to a letter from Elliott dated 15 May 1810. Elliott had sent over 200 specimens with his letter, to Muhlenberg for exchange and identification. Muhlenberg replied to Elliott with partial and complete identifications for specimens 32 through 80 and 201 through 238. Specimen number 215 was labeled "*Carex verrucosa* Schkuhr, *flacca* affin ". This taxon described by Schkuhr was not located in the literature. It is unclear why Muhlenberg used this authority; however this name is not validly published and is therefore not an accepted authority for the taxon. Three years later, Muhlenberg (1813) published a vascular plant checklist for North America, in which he listed *C. verrucosa* without an authority. Muhlenberg's (1817) description of *C. verrucosa* validly published the taxon with him as the authority. Elliott's (1824) description of *C. verrucosa*, stated that he collected a specimen many years prior in southern South Carolina between Stono and the Combahee Ferry (inferring collection either in Charleston, Dorchester, Colleton or Hampton counties). The specimen mentioned is most likely the specimen mentioned in correspondence from Muhlenberg to Elliott (Elliott 215 (PH)).

It is possible that Elliott 215 (PH) is a specimen on which Muhlenberg based the description of *C. verrucosa*. The type description by Muhlenberg (1817) describes *C. verrucosa* as having five lateral spikes, however the Elliott 215 (PH) specimen has six lateral spikes. This discrepancy makes it problematic to conclude that Muhlenberg based the *C. verrucosa* description on Elliott 215 (PH). It would not be a stretch to lectotypify Elliott 215 (PH), if Muhlenberg had described *C. verrucosa* with a range for spike number.

Elliott 215 (PH) is a valuable specimen because it is labeled as *C. verrucosa* by Muhlenberg. The *C. verrucosa* type description does not distinctly separate it from *C. glaucescens*. The specimen is useful in that it indicates what Muhlenberg described as *C. verrucosa*. The Elliott 215 (PH) specimen will not be lectotypified for *C. verrucosa* within this manuscript.

Artificial Dichotomous Key to Carex Section Glaucescentes in North America

1a. Pistillate scale tapered into an awn, sometimes minutely emarginate; perigynia inflated and abruptly narrowing into a beak 0.7 to 1.4 mm long, veins prominent with (12-) 14-18 (-20). (Fig. 20) ________________________________ ***C. joorii***

1b. Pistillate scale emarginate to retuse at awn base; perigynia not inflated and nearly beakless at 0.2 to 0.5 mm long (some *C. glaucescens* may be consider longer), veins prominent to somewhat obscure with 2-12.

  2a. Perigynia rhombic, pedicel surrounded with perigynia tissue, 0.2-0.5 mm long, 0.2-0.5 mm wide; lowermost pistillate spike peduncles are generally erect. (Fig. 20) ___________________________________ ***C. verrucosa***

  2b. Perigynia elliptic to ovate, pedicel not surrounded with perigynia tissue, 0.1-0.2 mm long, 0.1-0.2 mm wide; lowermost pistillate spike peduncles are generally drooping. (Fig. 20) ___________________ ***C. glaucescens***

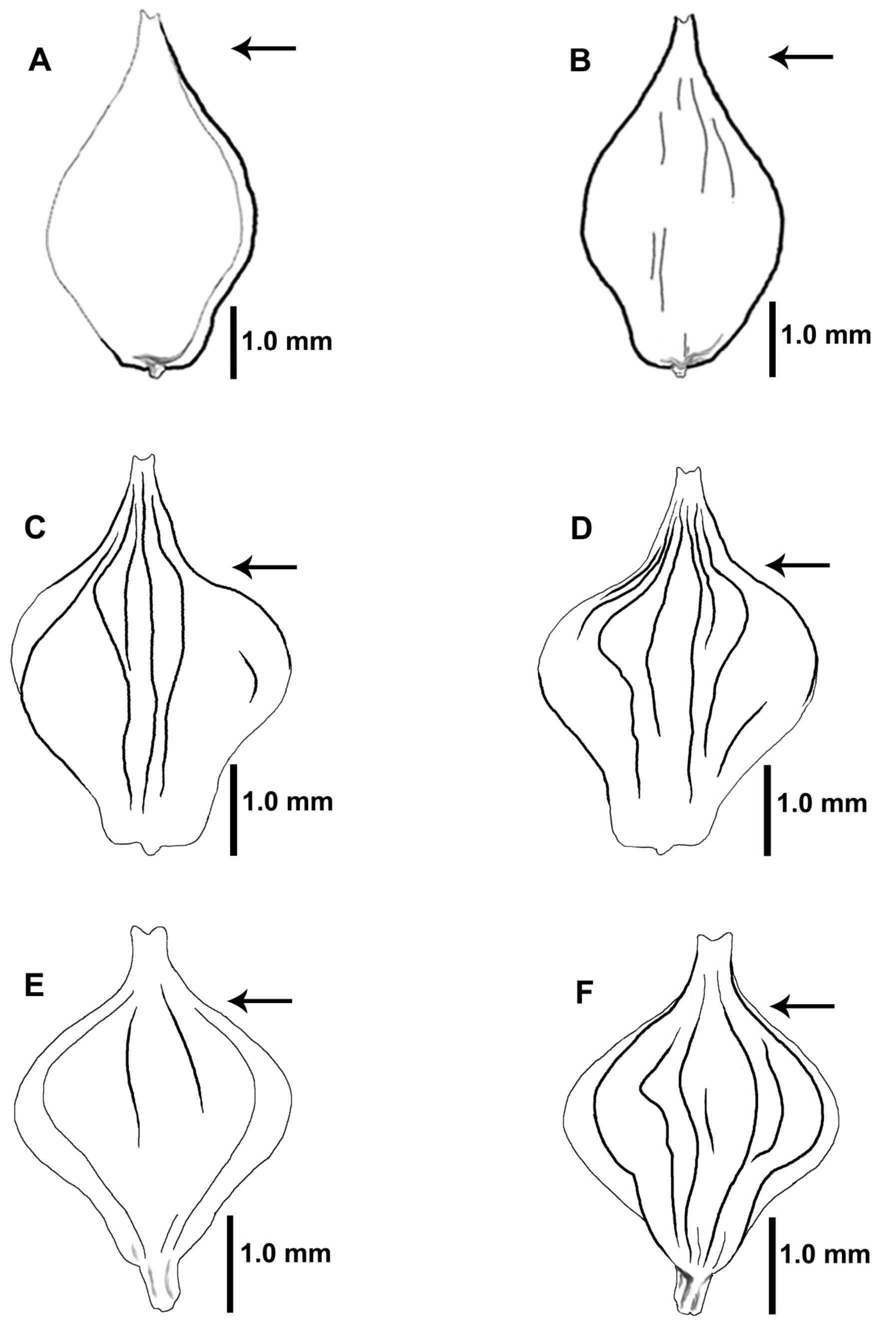

FIG. 20. Line drawings of perigynia from North American taxa of *Carex* section *Glaucescentes*. Arrows indicate beginning of beak. Dark longitudinal lines represent prominent veins. *C. glaucescens*: A. Abaxial view, B. Adaxial view, *C. joorii*: C. Abaxial view, D. Adaxial view, *C. verrucosa*: E. Abaxial view, F. Adaxial view.

Species Descriptions

Carex glaucescens Elliott, Sketch Bot. S. Carolina. 2: 553. 1824. TYPE not designated.

Carex glaucescens Elliott var *polystachys* M.A. Curtis, Amer. J. Sci. Arts 57: 410.1849.

Carex inundata Willd. *ex* Schltdl., Linnaea 10: 267. 1835.

Carex rufidula Steud., Syn. Pl. Glumac. 2: 220. 1885.

Carex sempervirens Schwein., Ann. Lyceum Nat. Hist. New York 1: 70. 1824, non Villars 1787.

Carex verrucosa Muhl. var. *glaucescens* A.W. Wood, Amer. Bot. Fl., ed. 2. 379. 1871.

Edritria glaucescens (Elliott) Raf., Good Book 26. 1840. Publication not viewed by author.

Robust perennials forming cespitose clumps. **Rhizomes** short, scaly and brown to black. **Culms** (58-) 79-114 (-150) cm tall, erect. **Leaves**: Abaxial sheath surfaces many veined; Adaxial sheath surfaces membranous, red to brown dotted, apically acute to rounded and sometimes fibrous splitting centrally; Blades extending beyond terminal spike, (2.4-) 3.8-6.0 (-7.1) mm wide; Abaxial blade surface papillose glaucous with one prominent central vein; Adaxial blade surface scabrous with many veins and sometimes 2 distinct veins forming a **M**-cross section; Blade margins revolute and antrorsely serrulate. **Ligules** minute, membranous, apically v-shaped and turning brown. **Inflorescences** (7-) 10-18 (-29) cm long; **Bracts** variable in length, but progressively shorter proximally to distally, generally the lowermost spike bract extends beyond the terminal spike, bracts with minute to erect rounded or acute appendages proximally. **Terminal spikes** assurgent to the rachis, 1 (-3) including reduced spikes, frequently staminate, rarely with pistillate spikelets, (1.3-) 2.8-5.4 (-7.7) cm long, (4.1-) 4.7-7.1 (-8.9) mm wide; peduncle 0.3-11.9 (-30+) cm long; staminate scales (1.3-) 5.0-7.6 (-8.5) mm long, 1.0-2.2 (-5.0) mm wide, apically emarginate to retuse with rounded to acute lobes, oblong, 3-veined with central vein extending into an antrorsely barbed awn. **Lateral spikes** pendulous to the rachis, 3-5 (-7) including lowermost pistillate spike, androgynecandrous or gynecandrous (0-numerous sterile or staminate distal spikelets, many central pistillate spikelets and (0-) 1-3 staminate proximal spikelets); peduncles drooping. *Uppermost pistillate spikes* (0.4-) 1.9-3.6 (-4.2) cm long, peduncles (0-) 0.4-2.7 (-6.2) cm long. *Second lowermost pistillate spikes* (2.1-) 2.8-4.6 (-6.3) cm long, peduncles (0.0-) 0.7-3.9 (-9.8) cm long. *Lowermost pistillate spikes* (2.2-) 2.7-4.4 (-5.6) cm long, peduncles (0.5-) 1.3-5.2 (-12.2) cm long, (0.2-) 0.3-0.5 (-0.6) mm wide. **Pistillate scales** apically emarginate to retuse with rounded to acute lobes, oblong, 3-veined with central vein extending into an (0.5-) 0.9-2.0 (-3.3) mm long antrorsely barbed awn, scale body shorter than perigynia, scale (2.5-) 3.5-4.8 (-6.1) mm long, (1.0-) 1.1-1.7 (-2.0) mm wide; **Perigynia** ascending to rarely divergent, elliptic to ovate, (3.0-) 3.4-4.1 (-4.7) mm long, (1.8-) 2.0-2.4 (-2.5) mm wide; Beak (0.2-) 0.3-0.5 (-0.7) mm long; Surfaces with clavate to terete and sometimes longitudinally troughed papillae; Faces and angles with 2-6 (-10) mostly indistinct veins including 2 distinct lateral veins (suture lines) extending into a bidentate beak; pedicel 0.1-0.2 mm long, 0.1-0.2 mm wide. **Achenes** triquetrous, obtrullate, (1.9-) 2.3-2.8 (-3.0) mm long, (1.7-)

1.8-2.1 (-2.3) mm wide; Surface of nonisodymetric epidermal cells with a central silica body; Style deciduous.

Phenology: (Jan-) Jul-Sep (-Nov).

Distribution: AL, FL, GA, LA, MD, MS, NC, SC, TN, TX and VA (Fig. 16). Distribution of *Carex glaucescens* is along the southeastern Gulf coastal plains, north and east into the Piedmont province and Appalachian plateau and northeastward into the Atlantic coast plain.

Habitat: margins of streams, shallow ponds, logged pine plantations, roadside ditches, seasonally wet flatwood ponds and seasonally wet meadows; sandy, loamy and clay soils.

Carex joorii Bailey, Proc. Amer. Acad. Arts. 22(1): 72, 1886. TYPE: U.S.A., LA: Comite Swamp, near Baton Rouge, J.F. Joor s.n., 5 Aug 1885: (HOLOTYPE: BH!).

Robust perennials forming cespitose clumps. **Rhizomes** short, sometimes curved, scaly and brown to black. **Culms** (23-) (62-99) (-119) cm tall, erect. **Leaves**: Abaxial sheath surfaces many veined; Adaxial sheath surfaces membranous, red to brown dotted, apically acute to rounded and sometimes fibrous; Blades extending beyond terminal spike, (2.9-) 3.9-5.3 (-5.5) mm wide, Abaxial blade surface papillose glaucous to somewhat glabrate with one prominent vein, Adaxial blade surface scabrous to smooth with many veins and sometimes 2 distinct veins forming a **M**-cross section; Blade margins revolute and antrorsely serrulate. **Ligules** minute, membranous, apically v-shaped and turning brown. **Inflorescences** (7-) 13-24 (-29) cm long, **Bracts** variable in length, but progressively shorter proximally to distally, generally the lowermost spike bract extends beyond the terminal spike, bracts with minute to erect rounded or acute appendages. **Terminal spikes** assurgent to the rachis, 1 (-3) including reduced spikes, staminate, rarely with pistillate spikelets, (2.0-) 3.1-5.4 (-6.0) cm long, (2.5-) 3.4-5.9 (-9.5) mm wide; peduncle (3-) 1.5-4.6 (-6.2) cm long; staminate scales (4.1-) 5.1-7.5 (-9.1) mm long, (1.1-) 1.3-1.6 (-1.8) mm wide apically acute, ovate to oblong, 3-veined with central vein extending into an antrorsely barbed awn. **Lateral spikes** pendulous to the rachis, 4-7 spikes including lowermost pistillate, androgynecandrous or rarely gynecandrous (0-numerous sterile or staminate distal spikelets, many central pistillate spikelets and (0-) 1-3 staminate proximal spikelets); Peduncles drooping. *Uppermost pistillate spikes* (0.8-) 1.6-3.4 (-5.5) cm long; peduncles 0.0-1.0 (-2.7) cm long. *Second lowermost pistillate spikes* (2.3-) 2.9-4.9 (-6.7) cm long; peduncles (0.6-) 1.2-3.6 (-5.3) cm long. *Lowermost pistillate spike*s (2.6-) 3.2-5.3 (-6.5) cm long; staminate distal (0-) 0.8-7.3 mm long; peduncles (2.0-) 2.6-6.2 (-7.8) cm long, 0.3-0.5 (-0.6) mm wide. **Pistillate scales** apically acute, ovate, 3-veined with central vein extending into an antrorsely barbed awn (0.3-) 0.7-1.5 (-1.6) mm long, scale body shorter than perigynia, scale (2.5-) 3.3-4.5 (-5.3) mm long, (1.2-) 1.3-1.7 (-2.1) mm wide. **Perigynia** squarrose, rhombic, (3.4-) 3.6-4.3 (-4.9) mm long, (2.1-) 2.5-2.9 (-3.1) mm wide; Beak (0.7-) 0.8-1.1 (-1.4) mm long; Surfaces with concave reticulate with absent, clavate or rounded papillae, generally with clavate papillae apically and rounded to absent papillae below beak; Faces and angles with 13-16 distinct veins, including 2 suture lines which sometimes extend to form a bidentate beak; Pedicel (0.0-) 0.1-0.1 (-0.3) mm wide, (0.0) 0.1-0.1 (-0.2) mm long. **Achenes** triquetrous, obtrullate, (2.3-) 2.5-2.8 (-2.9) mm long, (1.9-) 2.2-2.6 (-2.8) mm wide; Surface of nonisodymetric epidermal cells with a central silica body; Style deciduous.

Phenology: (Apr-) Jul-Oct (-Nov).

Distribution: AR, FL, GA, KY, LA, MD, MO, MS, NC, SC, TN, TX and VA (Fig. 17). Distribution of *C. joorii* is along the southeastern coastal plains, north and east into the unglaciated plains, the Piedmont province, the Appalachian plateau, the valley and ridge province, the interior low plateau and eastward into the Atlantic coast plain.

Habitat: margins of streams, shallow ponds, logged pine plantations, roadside ditches, seasonally wet flatwood ponds and seasonally wet meadows; sandy, loamy and clay soils.

Carex verrucosa Muhl., Descr. Gram. 261. 1817. TYPE: not designated. Potential specimen for lectotypification by author: <u>Elliott</u> <u>215</u> (BH).

Carex glaucescens Elliott var. *androgyna* M.A. Curtis, Amer. J. Sci. Arts 44:84. 1843.

Carex verrucosa Muhl. var. *androgyna* (M.A. Curtis) Dewey, Amer. J. Sci. Arts 48: 140. 1845.

Carex macrokolea Steud., Syn. Pl. Glumac. 2: 223. 1855.

Carex brasiliensis A. St.-Hil. var. *gracilis* Boeck., Linnaea 41: 292. 1877.

Carex glaucescens Ell. forma *macrokolea* (Steud.), Kükenthal in Engler, Pflanzenr. 4 (38): 733. 1909.

Robust perennials forming cespitose clumps. **Rhizomes** short, scaly, brown to black. Culms (63-) (80-119 (-157) cm tall, erect. **Leaves** basal, extending beyond the terminal spike, (3-) (4.2-6.8) (-8) mm wide, abaxial surface papillose glaucous with one prominent central vein, adaxial surface scabrous with many veins, margins revolute and barbed. **Abaxial sheath surfaces** many veined. **Adaxial sheath surfaces** membranous, red to brown dotted, apex rarely intact, fibrous. **Ligules** minute, membranous, apically acute apically v-shaped and turning brown. **Inflorescences** (8-) 12-28 (-34) cm long, **Bracts** variable in length, progressively shorter from base to apex of inflorescence, generally the lowermost spike bract extends beyond the terminal spike. **Auricles** erect and emarginate to rarely tapered. **Terminal spikes**, staminate or gynecandrous and rarely androgynecandrous or solely pistillate, 2.7-5.0 cm long, 4.2-10.7 mm wide; peduncle 0.31-14.4 (-30.8) cm long; staminate scales 5.3-8.0 mm long, 1.1-1.9 mm wide. **Lateral spikes** androgynecandrous or sometimes gynecandrous (0-numerous distal staminate spikelets, many central pistillate spikelets and (0-) 1-3 proximal staminate spikelets), 3-7 spikes including lowermost pistillate, peduncles erect. *Uppermost pistillate spikes* (0.8-) 1.4-2.9 (-3.7) cm long, peduncles 0-0.5 (-1.2) cm long. *Second lowermost pistillate spikes* (1.5-) 2.6-4.5 (-5.2) cm long, peduncles (0.2-) 0.6-1.7 (-2.8) cm long. *Lowermost pistillate spikes* (2.0-) 2.8-4.7 (-6.1)cm long, peduncles (0.7-) 1.1-4.7 (-8.4) cm long, (0.3-) 0.4-0.6 (-0.7) mm wide, staminate distal 0-1.5 (-5.9) mm long. **Pistillate scales** emarginate to retuse with rounded to acute lobes, 3-veined with central vein extending into an awn, scale body shorter than perigynia, scale (3.6-) 3.9-5.7 (-7.0) mm long, 1.1-2.0 (-4.1) mm wide; awn antrorsely barbed, (4.0-) 1.1-2.0 (-3.7) mm long. **Perigynia** rhombic, papillose, (3.2-) 3.4-4.2 (-4.6) mm long, (2.2-) 2.4-2.7 (-3.1) mm wide, beak length (0.1-) 0.2-0.6 (-0.9) mm long, veins faint, (4-) 8-14 (-16); pedicel 0.2-0.4 (-0.5) mm long, 0.2-0.4 (-0.5) mm wide. **Achenes** triquetrous, obtrullate, (2.2-) 2.8-2.8 (-3.2) mm long, (2.1-) 2.3-2.6 (-3.0) mm; Surface of nonisodymetric epidermal cells with a central silica body; Style deciduous.

Phenology: (Feb-) Mar-May (-Dec).

Distribution: AL, FL, GA, LA, MS, NC, SC and TX (Fig. 18). Distribution of *Carex verrucosa* is along the Gulf coast plains eastward into the Atlantic coast plain.

Habitat: shallow ponds, roadside ditches and flatwood ponds; sandy, loamy and clay soils.

CONCLUSIONS

Currently accepted North America taxa in *Carex* section *Glaucescentes* should retain species rank. The taxa are separated to species by morphology, geographical distribution, phenology, statistical analysis and hybridization characteristics. Qualitative and quantitative morphological characters that delimit the three taxa are presented in an artificial dichotomous key and species descriptions. Some previously used characters in current keys (Godfrey & Wooten 1979; Standley 2002), were found to separate the taxa when wording or ranges were changed. Other characters were found to inconsistently separate the taxa. The species descriptions and artificial dichotomous key produced from this manuscript should increase the accuracy of identification for these taxa.

Specifically, *C. joorii* is separated from the other taxa by having inflated, squarrose perigynia, 12 or more prominent veins on the perigynia and perigynia beak length, wider leaves and a tapered scale. *Carex verrucosa* has erect peduncles (rarely the lowermost spike drooping), rhombic, but not inflated perigynia and a pedicel surrounded with perigynia tissue that is generally wider and longer than that of *C. joorii* and *C. glaucescens*. *Carex glaucescens* has elliptic to ovate and longer than wide perigynia.

Geographical distributions overlap within the coastal plain region for all three taxa, with *C. verrucosa* extending furthest south. *Carex joorii* has the widest distribution, followed by *C. glaucescens* and finally *C. verrucosa* with the narrowest distribution. *Carex joorii* and *C. glaucescens* are both late summer to early fall flowering species, which differentiates them from the spring flowering species *C. verrucosa*.

PCA separated the taxa into 3 clusters, which align with the accepted taxa, *C. glaucescens*, *C. joorii* and *C. verrucosa* based on type descriptions, *Carex joorii* and *C. verrucosa* should be considered separate species because they hybridize to produce infertile offspring.

The holotype specimen for *C. joorii* was located. Muhlenberg and Elliott did not designate type specimens for C. verrucosa or *C. glaucescens*, respectively, and one was not found in herbaria.

Further research for the section should include thorough sampling from sympatric populations containing all three taxa, along with evaluation of reproductive methods. Morphological characters that should be further evaluated include length of the leaf sheath and rhizome inner node length. These characters may be of little taxonomic value, however I suspect that *C. verrucosa* has longer sheaths and that *C. joorii* has longer inner-nodes.

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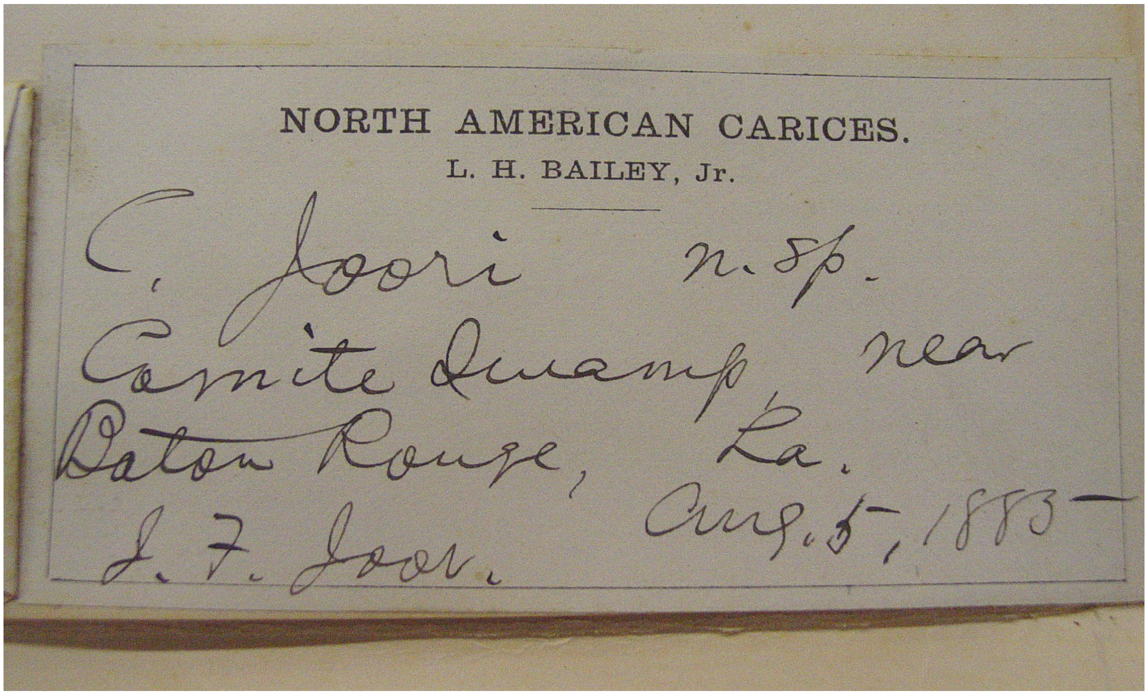
APPENDIX A

TYPE IMAGES OF *CAREX JOORII*


NORTH AMERICAN CARICES.

L. H. BAILEY, Jr.

C. Joori n. sp.
Comite Swamp near
Baton Rouge, La.
J. F. Joor. Aug. 5, 1883


L. H. BAILEY
CORNELL
UNIV.
HORTORIUM
CAREX
L. H. BAILEY
NORTH AMERICAN CARICES.
L. H. BAILEY, Jr.
C. Joori n. sp.
Comite Swamp near
Baton Rouge, La.
J. F. Joor. Aug. 5, 1888

APPENDIX B

ASSOCIATED SPECIES OF *CAREX* SECTION *GLAUCESCENTES*

	SPECIES	AUTHORITY	SOURCE/s
1	*Acer rubrum var. drummondii*	L., (Hook. & Arn. ex Nutt.) Sarg.	Weakley et al. 1998
2	*Acer rubrum var. rubrum*	L.	Weakley et al. 1998
3	*Alnus serrulata*	(Dryand *ex* Ait.) Willd.	Weakley et al. 1998
4	*Amsonia glaberrima*	Woods.	Weakley et al. 1998
5	*Amsonia tabernaemontana*	Walt.	D.A. Kruse 812
6	*Andropogon capillipes*	Nash	Weakley et al. 1998
7	*Andropogon glomeratus*	(Walt.) B.S.P.	Weakley et al. 1998
8	*Andropogon virginicus*	L.	Weakley et al. 1998
9	*Aristida palustris*	(Chapm.) Vasey	Weakley et al. 1998
10	*Aronia arbutifolia*	(L.) Ell.	Weakley et al. 1998
11	*Arundinaria gigantea*	(Walt.) Muhl.	Weakley et al. 1998
12	*Asclepias perennis*	Walt.	Weakley et al. 1998
13	*Bacopa caroliniana*	(Walt.) Robins.	Weakley et al. 1998
14	*Bartonia virginiana*	(L.) B.S.P.	Weakley et al. 1998
15	*Berchemia scandens*	(Hill) K. Koch	Weakley et al. 1998
16	*Bidens discoidea*	(T. & G.) Britt.	Weakley et al. 1998
17	*Bignonia capreolata*	L.	Weakley et al. 1998
18	*Boehmeria cylindrica*	(L.) Sw.	Weakley et al. 1998
19	*Botrychium dissectum*	Spreng.	Weakley et al. 1998
20	*Brasenia schreberi*	J. F. Gmel.	Weakley et al. 1998
21	*Brunnichia ovata*	(Walt.) Shinners	Weakley et al. 1998
22	*Cabomba caroliniana*	Gray	Weakley et al. 1998
23	*Calamagrostis coarctata*	(Torr.) Eat.	Weakley et al. 1998
24	*Cardiospermum halicacabum*	L.	Weakley et al. 1998
25	*Carex caroliniana*	Schwein.	D.C. McLaughlin

26	*Carex crinita*	Lam.	Weakley et al. 1998
27	*Carex festucacea*	Willd.	D.C. McLaughlin
28	*Carex flaccosperma*	L. H. Dewey	D.C. McLaughlin
29	*Carex frankii*	Kunth.	D.C. McLaughlin 506
30	*Carex gigantea*	Rudge	Weakley et al. 1998
31	*Carex intumescens*	Rudge	Weakley et al. 1998
32	*Carex lonchocarpa*	Willd.	Weakley et al. 1998
33	*Carex striata*	Michx.	Weakley et al. 1998
34	*Carex triangularis*	Boeck.	D.C. McLaughlin
35	*Carex turgescens*	Torr.	Weakley et al. 1998
36	*Carex venusta var. minor*	Dewey, Boeckl.	Weakley et al. 1998
37	*Carpinus caroliniana*	Walt.	Weakley et al. 1998
38	*Carya alba*	(Miller) K. Koch	Weakley et al. 1998
39	*Carya aquatica*	(Michx. f.) Nutt.	Weakley et al. 1998
40	*Carya glabra*	(Mill.) Sweet	Weakley et al. 1998
41	*Carya ovata*	(Miller) K. Koch	Weakley et al. 1998
42	*Cephalanthus occidentalis*	L.	D.C. McLaughlin, Weakley et al. 1998
43	*Chasmanthium latifolium*	(Michx.) Yates	Weakley et al. 1998
44	*Chasmanthium ornithorhynchum*	(Steud.) Yates	Weakley et al. 1998
45	*Chasmanthium sessiliflorum*	(Poir.) Yates	Weakley et al. 1998
46	*Chionanthus virginicus*	L.	Weakley et al. 1998
47	*Cladium jamaicense*	Crantz.	D.A. Kruse 489
48	*Clethra alnifolia*	L.	Weakley et al. 1998
49	*Cliftonia monophylla*	(Lam.) Sarg.	Weakley et al. 1998
50	*Coreopsis linifolia*	Nutt.	Weakley et al. 1998
51	*Coreopsis nudata*	Nutt.	Weakley et al. 1998

52	*Cornus florida*	L.	Weakley et al. 1998
53	*Cornus foemina*	Mill.	Weakley et al. 1998
54	*Crataegus marshallii*	Egglston	Weakley et al. 1998
55	*Crataegus viridis*	L.	Weakley et al. 1998
56	*Cyperus erythrorhizos*	Muhl.	D.C. McLaughlin 483, Weakley et al. 1998
57	*Cyperus haspan*	L.	D.C. McLaughlin 485
58	*Cyrilla parvifolia*	Raf.	Weakley et al. 1998
59	*Cyrilla racemiflora*	L.	Weakley et al. 1998
60	*Dichanthelium boscii*	(Poir.) Gould & C.A. Clark	Weakley et al. 1998
61	*Dichanthelium longiligulatum*	(Nash) Freckmann	D.C. McLaughlin
62	*Dichanthelium scabriusculum*	(Ell.) Gould & C.A. Clark	Weakley et al. 1998
63	*Diodia virginiana*	L.	D.C. McLaughlin 438
64	*Dulichium arundinaceum*	(L.) Britt.	Weakley et al. 1998
65	*Echinodorus cordifolius*	(L.) Griseb.	Weakley et al. 1998
66	*Eleocharis equisetoides*	(Ell.) Torr.	Weakley et al. 1998
67	*Eleocharis melanocarpa*	Torr.	Weakley et al. 1998
68	*Eleocharis microcarpa*	Torr.	D.C. McLaughlin 402B, D.A. Kruse 803, Weakley et al. 1998
69	*Eleocharis montana*	(Kunth in H.B.K.) Roem. & Schult.	D.A. Kruse 597
70	*Eleocharis montevidensis*	Kunth.	D.A. Kruse *494* , 823
71	*Eleocharis quadrangulata*	(Michx.) Roem. & Schult.	D.C. McLaughlin 753, Weakley et al. 1998
72	*Eleocharis tuberculosa*	(Michx.) R.&S.	D.C. McLaughlin 414, D.A. Kruse 818, 500, Weakley et al. 1998
73	*Eleocharis vivipara*	Link.	D.A. Kruse 596
74	*Elephantopus carolinianus*	Raeusch.	Weakley et al. 1998
75	*Erigeron vernus*	(L.) Torr. & Gray	Weakley et al. 1998
76	*Eriocaulon compressum*	Lam.	Weakley et al. 1998

77	*Eriocaulon decangulare*	L.	Weakley et al. 1998
78	*Eupatorium leptophyllum*	DC.	Weakley et al. 1998
79	*Eupatorium mohrii*	Greene	Weakley et al. 1998
80	*Eupatorium semiserratum*	DC.	Weakley et al. 1998
81	*Euthamia leptocephala*	(T. & G.) Greene	Weakley et al. 1998
82	*Euthamia tenuifolia*	(Pursh) Nutt.	Weakley et al. 1998
83	*Fagus grandifolia*	Ehrh.	Weakley et al. 1998
84	*Fimbristylis autumnalis*	(L.) R.&S.	D.C. McLaughlin 496
85	*Fraxinus caroliniana*	Mill.	Weakley et al. 1998
86	*Fraxinus profunda*	(Bush) Bush	Weakley et al. 1998
87	*Fuirena bushii*	Kral	Weakley et al. 1998
88	*Gaylussacia mosieri*	Small	Weakley et al. 1998
89	*Gelsemium rankinii*	(L.) Ait. f.	Weakley et al. 1998
90	*Gratiola brevifolia*	Raf.	D.C. McLaughlin, 403, 432, Weakley et al. 1998
91	*Hamamelis virginiana*	L.	Weakley et al. 1998
92	*Helenium drummondii*	H. Rock	Weakley et al. 1998
93	*Heliotropium indicum*	L.	Weakley et al. 1998
94	*Hibiscus moscheutos*	L.	Weakley et al. 1998
95	*Hydrocotyle spp.*	L.	Weakley et al. 1998
96	*Hydrolea ovata*	Choisy	D.C. McLaughlin 488, Weakley et al. 1998
97	*Hypericum brachyphyllum*	(Spach) Steud.	Weakley et al. 1998
98	*Hypericum chapmanii*	P. Adams	Weakley et al. 1998
99	*Hypericum galioides*	Lam.	Weakley et al. 1998
100	*Hypericum hypericoides*	L.	Weakley et al. 1998
101	*Hyptis alata*	(Raf.) Shinners	Weakley et al. 1998
102	*Ilex coriacea*	(Pursh.) Chapm.	Weakley et al. 1998

103	*Ilex decidua*	Walt.	Weakley et al. 1998
104	*Ilex glabra*	(L.) Gray	Weakley et al. 1998
105	*Ilex myrtifolia*	Walt.	Weakley et al. 1998
106	*Ilex verticillata*	(L.) Gray	Weakley et al. 1998
107	*Ilex vomitoria*	Soland. In Ait.	Weakley et al. 1998
108	*Isoetes melanopoda*	J. Gay & Durieu ex Durieu	D.C. McLaughlin, D.A. Kruse 826
109	*Itea virginica*	L.	Weakley et al. 1998
110	*Juncus brachycarpus*	Engelm. In A. Gray	D.A. Kruse 822
111	*Juncus difusissumus*	Buckl.	D.C. McLaughlin 413, D.A. Kruse 811
112	*Juncus effusus*	L.	D.A. Kruse 808, Weakley et al. 1998
113	*Juncus elliottii*	Coville	D.A. Kruse 821
114	*Juncus marginatus*	Rostk.	D.C. McLaughlin 435, Weakley et al. 1998
115	*Juncus nodatus*	Cov.	D.C. McLaughlin 402A
116	*Juncus polycephalus*	Michx.	D.C. McLaughlin 433, Weakley et al. 1998
117	*Juncus repens*	Michx.	D.C. McLaughlin 408, Weakley et al. 1998
118	*Juncus tenuis*	Willd.	D.A. Kruse 824, 810
119	*Juncus validus*	Cov.	Weakley et al. 1998
120	*Justicia ovata*	(Walt.) Lindau	D.C. McLaughlin 406, Weakley et al. 1998
121	*Lachnocaulon beyrichianum*	Sporleder ex Koern.	Weakley et al. 1998
122	*Lauchnocaulon anceps*	(Walt.) Morong.	D.A. Kruse 492
123	*Leersia hexandra*	Sw.	D.C. McLaughlin 486, D.A. Kruse 596, Weakley et al. 1998
124	*Leersia lenticularis*	Michx.	Weakley et al. 1998
125	*Leersia oryzoides*	(L.) Sw.	Weakley et al. 1998
126	*Lemna minor*	L.	Weakley et al. 1998
127	*Leucothoe racemosa*	(L.) DC.	Weakley et al. 1998

128	*Limnobium spongia*	(Bosc) L. C. Rich. *ex* Steud.	Weakley et al. 1998
129	*Liquidambar styraciflua*	L.	D.C. McLaughlin, Weakley et al. 1998
130	*Ludwigia microcarpa*	Michx.	Weakley et al. 1998
131	*Ludwigia pilosa*	Walt.	Weakley et al. 1998
132	*Ludwigia sphaerocarpa*	Ell.	Weakley et al. 1998
133	*Ludwigia suffruticosa*	Walt.	Weakley et al. 1998
134	*Lycopodiella alopecuroides*	(L.)	Weakley et al. 1998
135	*Lycopodiella appressa*	(Chapman) Cranfill	Weakley et al. 1998
136	*Lycopodiella caroliniana*	(L.) Pichi Sermolli	Weakley et al. 1998
137	*Lycopus rubellus*	Moench.	Weakley et al. 1998
138	*Lyonia ligustrina*	(L.) DC.	Weakley et al. 1998
139	*Lyonia lucida*	(Lam.) K. Koch	Weakley et al. 1998
140	*Magnolia grandiflora*	L.	Weakley et al. 1998
141	*Magnolia virginiana*	L.	Weakley et al. 1998
142	*Mecardonia acuminata*	(Walt.) Small	Weakley et al. 1998
143	*Mitchella repens*	L.	Weakley et al. 1998
144	*Mitreola petiolata*	(J.F. Gmel.) Torr. & A. Gray	D.C. McLaughlin 481
145	*Mnesithia rugosum*	(Michx.) Koning & Sosef	D.C. McLaughlin 480, 482
146	*Myrica cerifera*	L.	D.A. Kruse 636, Weakley et al. 1998
147	*Myrica heterophylla*	Raf.	D.A. Kruse 417, Weakley et al. 1998
148	*Nelumbo lutea*	(Willd.) Pers.	Weakley et al. 1998
149	*Nymphoides aquatica*	(Gmel.) O. Ktz.	D.C. McLaughlin 490, D.A. Kruse 634
150	*Nyssa aquatica*	L.	Weakley et al. 1998
151	*Nyssa biflora*	Walt.	Weakley et al. 1998
152	*Nyssa ogeche*	L.	Weakley et al. 1998
153	*Osmunda cinnamomea*	L.	Weakley et al. 1998

154	*Oxypolis filiformis*	(Walt.) Britt.	Weakley et al. 1998
155	*Panicum gymnocarpon*	Ell.	Weakley et al. 1998
156	*Panicum hemitomon*	Schult.	Weakley et al. 1998
157	*Panicum hians*	Ell.	D.A. Kruse 825
158	*Panicum tenerum*	Beyr. *ex* Trin.	Weakley et al. 1998
159	*Panicum verrucosum*	Muhl.	Weakley et al. 1998
160	*Panicum virgatum*	L.	Weakley et al. 1998
161	*Pedicularis canadensis*	L.	Weakley et al. 1998
162	*Persea palustris*	(Raf.) Sarg.	Weakley et al. 1998
163	*Physostegia purpurea*	Englem.	D.C. McLaughlin 431
164	*Pinus elliottii var. elliottii*	Engelm.	Weakley et al. 1998
165	*Pinus glabra*	Mill.	Weakley et al. 1998
166	*Pinus glabra*	Walt.	Weakley et al. 1998
167	*Pinus palustris*	L.	Weakley et al. 1998
168	*Pinus taeda*	L.	Weakley et al. 1998
169	*Planera aquatica*	(Walt.) J.F. Gmel.	Weakley et al. 1998
170	*Pluchea camphorata*	(L.) DC.	Weakley et al. 1998
171	*Polygonum hydropiperoides*	Michx.	D.C. McLaughlin 405, 410, Weakley et al. 1998
172	*Pontederia cordata*	L.	Weakley et al. 1998
173	*Populus heterophylla*	L.	Weakley et al. 1998
174	*Potamogeton spp.*	L.	Weakley et al. 1998
175	*Proserpinaca palustris*	L.	D.C. McLaughlin 411, Weakley et al. 1998
176	*Proserpinaca pectinata*	Lam.	Weakley et al. 1998
177	*Quercus alba*	L.	Weakley et al. 1998
178	*Quercus laurifolia*	Michx.	Weakley et al. 1998
179	*Quercus lyrata*	Walt.	Weakley et al. 1998

180	*Quercus michauxii*	Nutt.	Weakley et al. 1998
181	*Quercus nigra*	L.	Weakley et al. 1998
182	*Quercus pagoda*	Raf.	Weakley et al. 1998
183	*Quercus palustris*	Muench.	Weakley et al. 1998
184	*Quercus phellos*	L.	Weakley et al. 1998
185	*Quercus similis*	Ashe	Weakley et al. 1998
186	*Rhexia mariana*	L.	Weakley et al. 1998
187	*Rhexia virginica*	L.	Weakley et al. 1998
188	*Rhododendron canescens*	(Michx.) Sweet	Weakley et al. 1998
189	*Rhododendron viscosum*	(L.) Torr.	Weakley et al. 1998
190	*Rhynchospora caduca*	Ell.	D.A. Kruse 502, 809, Weakley et al. 1998
191	*Rhynchospora cephalantha*	Gray	Weakley et al. 1998
192	*Rhynchospora colorata*	(L.) Pfeifer	D.A. Kruse 817
193	*Rhynchospora corniculata*	(Lam.) Gray.	D.C. McLaughlin, 404, 412, 437, Weakley et al. 1998
194	*Rhynchospora elliottii*	A. Dietr.	D.C. McLaughlin 417, Weakley et al. 1998
195	*Rhynchospora fascicularis var. fascicularis*	(Michx.) Vahl	Weakley et al. 1998
196	*Rhynchospora globularis*	(Chapm.) Small	D.A. Kruse 816
197	*Rhynchospora glomerata*	(L.) Vahl.	D.C. McLaughlin 487, 497
198	*Rhynchospora inundata*	(Oakes) Fern.	Weakley et al. 1998
199	*Rhynchospora macrostachya*	Torr. *Ex* Gray	Weakley et al. 1998
200	*Rhynchospora microcarpa*	Gray	Weakley et al. 1998
201	*Rhynchospora perplexa*	Britt. Ex Small.	D.A. Kruse 490
202	*Rhynchospora rariflora*	(Michx.) Ell.	D.A. Kruse 819
203	*Rosa palustris*	Marsh.	Weakley et al. 1998
204	*Rudbeckia nitida var. texana*	Perdue	Weakley et al. 1998

205	*Sabal minor*	(Jacq.) Pers.	D.C. McLaughlin, Weakley et al. 1998
206	*Sabatia bartramii*	Wilbur	Weakley et al. 1998
207	*Sabatia campanulata*	(L.) Torr.	Weakley et al. 1998
208	*Saccharum baldwinii*	Spreng.	Weakley et al. 1998
209	*Sagittaria graminea*	Michx.	Weakley et al. 1998
210	*Sagittaria lancifolia*	L.	D.C. McLaughlin 439, D.A. Kruse 632
211	*Salix nigra*	Marsh.	Weakley et al. 1998
212	*Sambucus canadensis*	L.	Weakley et al. 1998
213	*Saururus cernuus*	L.	D.C. McLaughlin 409, D.A. Kruse 807, Weakley
214	*Scirpus cyperinus*	(L.) Kunth	Weakley et al. 1998
215	*Scleria baldwinii*	(Torr.) Steud.	Weakley et al. 1998
216	*Scleria georgiana*	Core	Weakley et al. 1998
217	*Scleria triglomerata*	Michx.	D.A. Kruse 491
218	*Scutellaria integrifolia*	L.	Weakley et al. 1998
219	*Sebastiana fruticosa*	(Batr.) Fern.	Weakley et al. 1998
220	*Smilax laurifolia*	L.	Weakley et al. 1998
221	*Smilax rotundifolia*	L.	Weakley et al. 1998
222	*Smilax walteri*	Pursh	Weakley et al. 1998
223	*Sparganium americanum*	Nutt.	D.A. Kruse, D.C. McLaughlin
224	*Sphagnum lescurii*	Sull. in Gray	Weakley et al. 1998
225	*Sphagnum macrophyllum*	Brid.	Weakley et al. 1998
226	*Spiranthes laciniata*	(Small) Ames	Weakley et al. 1998
227	*Stylisma aquatica*	(Walt.) Chapm.	Weakley et al. 1998
228	*Styrax americana*	Lam.	D.C. McLaughlin 509, Weakley et al. 1998
229	*Taxodium ascendens*	Brongn.	Weakley et al. 1998
230	*Taxodium distichum*	(L.) L. Rich.	Weakley et al. 1998

APPENDIX C

SPECIES ALLIANCES AND ASSOCIATIONS FROM THE INTERNATIONAL CLASSIFICATION OF ECOLOGICAL COMMUNITIES

ALLIANCE	ASSOCIATION	CAREX GLAUCECENS	CAREX JOORII	CAREX VERRUCOSA
***Fagus grandifolia* Temporarily Flooded Forest Alliance**		X	X	
	***Fagus grandifolia* - (*Magnolia grandiflora*) / *Hamamelis virginiana* / *Arundinaria gigantea* Forest** G3?	X	X	
***Quercus* (*phellos, nigra, laurifolia*) Temporarily Flooded Forest Alliance**		X	X	
	***Quercus phellos* - *Quercus nigra* - *Quercus alba* / *Chasmanthium sessiliflorum* Forest** G3, G4	X	X	
***Nyssa* (*aquatica, biflora, ogeche*) Pond Seasonally Flooded Forest Alliance**		X		X
	***Nyssa biflora* / *Ilex myrtifolia* / *Carex glaucescens* - *Eriocaulon compressum* Forest** G2, G3	X		
	***Nyssa ogeche* / *Ilex myrtifolia* / *Carex turgescens* - *Carex striata* Forest** G2?	X		X
***Taxodium ascendens* Seasonally Flooded Forest Alliance**		X		
	***Taxodium ascendens* / *Ilex myrtifolia* Depression Forest** G3?	X		
Nyssa aquatica - (Taxodium distichum) Semipermanently Flooded Forest Alliance		X		

Taxodium distichum Semipermanently Flooded Forest Alliance				
	Taxodium distichum / Lemna minor **Forest** G5	X		
Magnolia virginiana - Nyssa biflora **- (*Quercus laurifolia*) Saturated Forest Alliance**				
	Quercus laurifolia - Magnolia virginiana - Nyssa biflora / Chasmanthium ornithorhynchum **Forest** G2?	X		
Pinus elliottii - Magnolia virginiana - Nyssa biflora **- (*Taxodium ascendens*) Saturated Forest Alliance**		X		
	Pinus elliottii **var.** ***elliottii - Magnolia virginiana - Taxodium ascendens - Nyssa biflora / Polygala cymosa - Carex glaucescens*** **Forest** G2, G3	X		
Pinus elliottii - Taxodium ascendens **Saturated Woodland Alliance**		X		
	Pinus elliottii **var.** ***elliottii - Taxodium ascendens / Polygala cymosa - Rhynchospora*** **spp. Woodland** G2?	X		
Vaccinium formosum - Vaccinium fuscatum **Seasonally Flooded Shrubland Alliance**		X		
	Leucothoe racemosa - Vaccinium fuscatum - Smilax walteri **Shrubland** G1?	X		

***Aristida palustris - Andropogon* (*capillipes, glaucopsis*) - *Rhynchospora* spp. Seasonally Flooded Herbaceous Alliance**		X		X
	***Aristida palustris - Panicum virgatum - Eriocaulon compressum - Eleocharis equisetoides* Herbaceous Vegetation** G2, G3	X		X
***Panicum hemitomon* Seasonally Flooded Temperate Herbaceous Alliance**	***Panicum hemitomon - Gratiola brevifolia* Herbaceous Vegetation** G3?	X		
***Panicum verrucosum - Panicum rigidulum - Saccharum baldwinii* Seasonally Flooded Herbaceous Alliance**		X		

APPENDIX D

REPRESENTATIVE ANNOTATED HERBARIUM SPECIMENS USED TO CREATE *CAREX GLAUCESCENS* DISTRIBUTION MAPS

HERBARIUM	ACCESCION NUMBER	COLLECTOR	COLLECTION NUMBER	COLLECTION YEAR	JULIAN COLLECTION DATE	STATE	COUNTY/ PARISH
SWSL	—	R. Kral	56991	1975	223	AL	AUTAUGA
UNA	848	R.R. Haynes	7524	1979	219	AL	BALDWIN
SWSL	—	R. Kral	47903	1972	210	AL	BIBB
UNA	977	J.H. Wiersema	1299	1979	258	AL	CHILTON
UNA	863	R.R. Haynes	7456	1979	191	AL	CHOCTAW
SWSL	—	R. Kral	41129	1970	248	AL	CLARKE
SWSL	—	R. Kral	51266	1973	225	AL	COFFEE
UNA	878	J.S. Williams	51	1979	272	AL	COVINGTON
UNA	987	J.H. Wiersema	2056	1980	242	AL	ELMORE
UNA	23507	R.R. Haynes	9457	1994	227	AL	ESCAMBIA
SWSL	—	R. Kral	79092	1991	175	AL	GENEVA
UNA	992	J.H. Wiersema	2061	1980	254	AL	HALE
SWSL	—	J.R. MacDonald	2864	1993	201	AL	HOUSTON
SWSL	—	G.P. Wills	—	1960	201	AL	LEE
US	817420	C. Mohr	—	1878	214	AL	MOBILE
UNA	858	R.R. Haynes	8102	1980	217	AL	WASHINGTON
SWSL	—	C.T. Bryson	2668	1979	266	FL	ALACHUA
FLAS	44926	L.E. Arnold	—	1946	193	FL	BAKER
FLAS	107335	J. Beckner	1521	1966	181	FL	BAY
FLAS	131028	L. Conde	0	1977	187	FL	BRADFORD
FSU	93219	S. McDaniel	4798	1964	186	FL	CALHOUN
LL	—	E.L. Bridges	13860	1990	157	FL	CLAY
US	364797	Combs	131	1898	206	FL	COLUMBIA

FLAS	30892	—	—	1937	231	FL	DIXIE
FLAS	99866	D.B. Creager	606	1967	162	FL	DUVAL
NCU	6545	P.L. Redfearn	2763	1956	202	FL	ESCAMBIA
FSU	172153	L.C. Anderson	8286	1985	165	FL	FRANKLIN
FSU	174587	L.C. Anderson	9422	1986	135	FL	GULF
NCU	6547	J.R. Bozeman	10134	1967	170	FL	HAMILTON
NCSC	55497	R. Kral	2860	1956	201	FL	HOLMES
FLAS	186309	S. McDaniel	6561	1965	204	FL	JACKSON
NCSC	62147	R.K. Godfrey	54893	1956	175	FL	JEFFERSON
FLAS	73749	R. Kral	7659	1958	217	FL	LAKE
LL	—	E.L. Bridges	14053	1990	182	FL	LIBERTY
DUKE	137095	R.K. Godfrey	54010	1955	275	FL	MADISON
DUKE	365995	R.L. Wilbur	68319	1997	206	FL	NASSAU
FSU	186783	L.C. Anderson	15057	1994	189	FL	OKALOOSA
DUKE	26039	M.L. Singeltary	35	1938	81	FL	OSCEOLA
NCU	6543	R. Brinker	442	1941	218	FL	PENSACOLA
SWSL	—	S. McDaniel	6605	1965	205	FL	SANTA ROSA
FLAS	70015	A.P. Garber	—	1876	196	FL	ST. AUGUSTINE
FLAS	38655	L.E. Arnold	—	1941	287	FL	ST. JOHN'S
MICH	—	A.A. Reznicek	7604	1985	227	FL	WAKULLA
FLAS	195974	B. Herring	1431	1998	211	FL	WALTON
FSU	97737	S. McDaniel	6509	1965	195	FL	WASHINGTON
NCU	6558	J.R. Bozeman	9330	1967	160	GA	APPLING
NCU	6559	P.R. Cowart	8	1971	207	GA	BALDWIN

DUKE	260087	W.H. Duncan	12876	1951	222	GA	BARTOW
FLAS	6437	P.C. Lemon	—	1943	235	GA	BERRIEN
MICH	—	R.L. Lane, Jr.	1305	1967	252	GA	BIBB
LL	—	G.W. Ramsey	169	1969	180	GA	BROOKS
NCU	6562	D. Hall	206	1964	282	GA	BULLOCH
NCU	6598	J.E. Benedict	3328	1936	185	GA	CANDLER
MICH	—	R. Carter	8860	1991	190	GA	CHARLTON
FLAS	134106	W.H. Duncan	21255	1958	193	GA	CHATHAM
NLU	407330	V.E. McNeilus	98793	1998	230	GA	CLINCH
NCU	6568	W.R. Faircloth	2999	1965	264	GA	COOK
NCU	6567	J.R. Bozeman	5366	1966	187	GA	DODGE
FLAS	146155	R.L. Lane, Jr.	879	1967	175	GA	DOOLY
MICH	—	E.L. Bridges	17949	1991	232	GA	EARLY
TAES	—	D.J. Rosen	2273	2002	235	GA	ECHOLS
US	3155031	D. Eyles	6099	1939	172	GA	EFFINGHAM
NCU	6569	J.R. Bozeman	6392	1966	202	GA	GLYNN
MICH	—	A. Cronquist	5451	1948	188	GA	GRADY
NLU	416143	Crook	466	1998	197	GA	HARRIS
SWSL	—	V.E. McNeilus	88400	1988	228	GA	LANIER
NLU	384059	V.E. McNeilus	90657	1990	201	GA	LEE
SWSL	—	S.B. Jones	24622	1984	260	GA	LIBERTY
NCU	6571	J.R. Bozeman	10286	1967	174	GA	LONG
US	3283545	M.T. Strong	1041	1993	222	GA	LOWNDES
NLU	281370	R.A. Norris	5427	1987	234	GA	MACON

MICH	—	S.D. Jones	10347	1993	300	LA	TANGIPAHOA
DUKE	205124	J.W. Thieret	27768	1967	247	LA	VERNON
NLU	188708	R.D. Thomas	77310	1981	178	LA	WASHINGTON
NLU	191902	R.D. Thomas	78408	1981	256	LA	WINN
US	3262833	W.D. Longbottom	3317	1992	230	MD	WICOMICO
DUKE	365157	M.H. Alford	1779	1998	285	MS	AMITE
SWSL	—	C.T. Bryson	11855	1992	216	MS	FORREST
NCU	6586	S.B. Jones	2158	1964	199	MS	GEORGE
MICH	—	C.T. Bryson	14943	1995	206	MS	GREENE
SWSL	—	C.T. Bryson	10839	1991	238	MS	HANCOCK
NCU	6588	S.M. Tracy	5968	1899	210	MS	HARRISON
MICH	—	S.R. Hill	22411	1991	194	MS	JACKSON
SWSL	—	C.T. Bryson	14220	1994	227	MS	LAMAR
SWSL	—	C.T. Bryson	10148	1990	224	MS	LOWNDES
NLU	376564	C.T. Bryson	14041	1994	210	MS	MARION
SWSL	—	S. McDaniel	24223	1980	214	MS	PEARL RIVER
SWSL	—	C.T. Bryson	14294	1994	250	MS	PERRY
SWSL	—	C.T. Bryson	14469	1994	271	MS	PIKE
SWSL	—	C.T. Bryson	6919	1987	228	MS	SCOTT
SWSL	—	C.T. Bryson	11006	1991	259	MS	STONE
SWSL	—	S. McDaniel	30900	1990	250	MS	WAYNE
NCSC	63411	A.E. Blair	1275	1966	282	NC	BEAUFORT
DUKE	128731	W.B. Fox	4092	1950	214	NC	BERTIE
NCU	6459	A.E. Radford	3013	1947	221	NC	BLADEN

NCSC	748	R.K. Godfrey	4858	1938	188	NC	BRUNSWICK
DUKE	9899	H.L. Blomquist	10351	1938	191	NC	CARTERET
NCU	6462	H.E. Ahles	47988	1958	211	NC	CHOWAN
DUKE	344948	R.L. Wilbur	49995	1988	229	NC	COLUMBUS
DUKE	343698	R.L. Wilbur	56191	1990	206	NC	CRAVEN
NCSC	42757	W.B. Fox	5623	1951	290	NC	CUMBERLAND
DUKE	128738	W.B. Fox	4166	1950	216	NC	CURRITUCK
NCU	6467	P.J. Crutchfield	4614	1959	238	NC	DARE
NCU	6471	H.E. Ahles	33086	1957	214	NC	DUPLIN
NCU	6472	A.E. Radford	36700	1958	195	NC	EDGECOMBE
NCU	6473	H.E. Ahles	54546	1958	289	NC	GATES
NCU	6475	A.E. Radford	36529	1958	192	NC	GREEN
MICH	—	A.E. Radford	36377	1958	192	NC	GREENE
NCU	6476	H.E. Ahles	17097	1956	200	NC	HALIFAX
FLAS	28440	R.K. Godfrey	—	1938	217	NC	HARNETT
NCSC	20986	W.B. Fox & R.K. Godfrey	2802	1949	204	NC	HERTFORD
NCU	6479	H.E. Ahles	29617	1957	177	NC	HOKE
NCU	6481	A.E. Radford	39070	1958	218	NC	HYDE
DUKE	159876	H.L. Blomquist	16883	1955	301	NC	JOHNSTON
DUKE	343696	R.L. Wilbur	56171	1990	200	NC	JONES
DUKE	343700	R.L. Wilbur	54097	1989	215	NC	LENOIR
DUKE	128727	W.B. Fox	4088	1950	214	NC	MARTIN
NCU	6488	A.E. Radford	19555	1956	282	NC	MONTGOMERY
US	1767882	R.K. Godfrey	5111	1938	195	NC	MOORE

DUKE	34203	R.K. Godfrey	5124	1938	199	NC	NASH
NCU	6490	D.J. Sieren	1672	1978	201	NC	NEW HANOVER
US	1768186	R.K. Godfrey	5819	1938	218	NC	ONSLOW
NCSC	14653	R.K. Godfrey	48336	1948	202	NC	PAMLICO
NCSC	844	J.C. Rabb	—	1940	224	NC	PASQUOTANK
NCU	6495	H.E. Ahles	32339	1957	207	NC	PENDER
DUKE	128697	W.B. Fox	4168	1950	217	NC	PERQUIMANS
DUKE	53516	H.L. Blomquist	6456	1931	208	NC	PITT
NCU	6497	A.E. Radford	14397	1956	205	NC	RICHMOND
NCU	6498	R. Kral	3417	1956	248	NC	ROBESON
DUKE	37023	R.K. Godfrey	5713	1938	217	NC	SAMPSON
DUKE	361680	J.W. Horn	1366	1998	232	NC	SCOTLAND
DUKE	128696	W.B. Fox	4107	1950	215	NC	TYRELL
DUKE	141167	W.B. Fox	1832	1948	230	NC	WAKE
US	2265533	W.B. Fox	4105	1950	215	NC	WASHINGTON
NCU	6505	W.W. Ashe	—	1898	319	NC	WASHINGTON
NCU	6506	A.E. Radford	37990	1958	209	NC	WILSON
NCU	6511	W.T. Batson	—	1951	267	SC	AIKEN
NCU	6512	C.R. Bell	3989	1956	181	SC	ALLENDALE
NCU	6513	H.E. Ahles	30469	1957	185	SC	BAMBERG
MICH	—	P.E. Hyatt	5753	1993	259	SC	BARNWELL
DUKE	280077	J.M. MacDougal	1497	1981	217	SC	BERKELEY
NLU	101065	T. Daggy	5147	1968	246	SC	CHESTERFIELD
NCU	6520	C.R. Bell	3696	1956	177	SC	COLLETON

MICH	—	J.B. Nelson	9608	1990	228	SC	DARLINGTON
NCU	6524	H.E. Ahles	32178	1957	206	SC	DILLON
NCU	6525	H.E. Ahles	31822	1957	201	SC	DORCHESTER
NCU	6527	A.E. Radford	44262	1961	236	SC	FAIRFIELD
NCU	6528	C.R. Bell	10895	1957	291	SC	FLORENCE
NCU	6530	H.E. Ahles	15725	1956	180	SC	HAMPTON
NCU	6531	H.E. Ahles	15517	1956	177	SC	JASPER
UNA	9067	C.N. Horn	7630	1993	232	SC	KERSHAW
US	585326	H.D. House	2613	1906	207	SC	LAUCASLER
NCU	6532	A.E. Radford	27323	1957	207	SC	LEE
NCU	6533	A.E. Radford	27211	1957	190	SC	LEXINGTON
NCU	6534	C.R. Bell	—	1958	183	SC	MARION
NCU	6535	A.E. Radford	15601	1956	222	SC	MARLBORO
NCU	6536	H.E. Ahles	31682	1957	200	SC	ORANGEBURG
MICH	—	J.B. Nelson	11628	1991	274	SC	RICHLAND
NCU	6538	A.E. Radford	26827	1957	189	SC	SALUDA
NCU	6540	A.E. Radford	27415	1957	208	SC	SUMTER
US	1837291	R.K. Godfrey	398	1939	191	SC	WILLIAMSBURG
SWSL	—	V.E. McNeilus	90907	1990	251	TN	BLEDSOE
US	2132993	W.B. Fox	5623	1951	280	TN	CUMBERLAND
US	1814699	H.K. Svenson	9183	1938	227	TN	GRUNDY
NLU	384064	J.A. Churchill	95121	1995	237	TN	VAN BUREN
LL	292965	E.L. Bridges	4500	1986	205	TX	ANGELINA
LL	—	P. Fryxell	3016	1978	204	TX	HARDIN

LL	—	E.L. Bridges	5674	1987	224	TX	JASPER
US	2297824	C.L. Lundell	14092	1945	199	TX	NEWTON
LL	292967	B.C. Tharp	43282	1941	102	TX	POLK
LL	292966	E.L. Bridges	5659	1987	224	TX	SABINE
TAES	158793	F.W. Gould	6523	1952	262	TX	SAN AUGUSTINE
SWSL	—	S.D. Jones	3707	1989	229	TX	TYLER
NLU	383621	W.J. Hayden	2880	1990	252	VA	CHESTERFIELD
NCU	6591	A. Carter	15	1974	263	VA	CUMBERLAND
NCU	6592	A.M. Harvill	17613	1967	215	VA	HENRICO
SWSL	—	L.L. Whitmarsh	469	1979	211	VA	ISLE OF WIGHT
NCU	6593	R. Kral	9510	1959	247	VA	NANSEMOND
US	356208	H. Kearney	1516	1898	190	VA	NORFOLK
NCU	6589	E.B. Neyes	—	—	—	VA	PORTSMOLLH
FLAS	125141	D.M.E. Ware	5600	1974	210	VA	PRINCE GEORGE
MICH	—	J.M. Fogg	9746	1935	255	VA	PRINCESS ANNE
US	3380826	M.T. Strong	2167	1999	253	VA	SUFFOLK
SWSL	—	B. Mikula	7631	1950	226	VA	SURRY
NCU	6596	R. Kral	11368	1960	241	VA	SUSSEX
SWSL	—	V.E. McNeilus	95577	1995	238	VA	VAN BUREN

APPENDIX E

REPRESENTATIVE ANNOTATED HERBARIUM SPECIMENS USED TO CREATE *CAREX JOORII* DISTRIBUTION MAPS

HERBARIUM	ACCESCION NUMBER	COLLECTOR	COLLECTION NUMBER	COLLECTION YEAR	JULIAN COLLECTION DATE*	STATE	COUNTY/ PARISH
UNA	948	D.L. Lentz	70	1980	242	AL	AUTAUGA
MICH	—	B. Keener	1464	1998	226	AL	BLOUNT
UNA	914	M. Birk	447	1995	264	AL	DALLAS
SWSL	—	R. Kral	56408	1975	224	AL	FAYETTE
UNA	904	M. Birk	115	1994	230	AL	HALE
SWSL	—	J.R. MacDonald	5083	1992	203	AL	HOUSTON
NCU	6439	D. Isely	4893	1946	216	AL	LIMESTONE
SWSL	—	C.T. Bryson	3099	1980	220	AL	MADISON
UNA	964	J.H. Wiersema	1961	1980	185	AL	MARENGO
UNA	999	R.R. Haynes	8194	1980	218	AL	PERRY
SWSL	—	S. McDaniel	9769	1967	259	AL	PICKENS
SWSL	—	R. Kral	47958	1972	211	AL	PIKE
DUKE	42039	D.S. Correll	8325	1937	251	AL	SAINT CLAIR
US	3164922	D.S. Correll	8325	1937	251	AL	ST. CLAIR
UNA	944	S. McDaniel	9917	1967	280	AL	WASHINGTON
SWSL	—	P.O. DeWitt	68691	1974	183	AR	ARKANSAS
NLU	265332	R.D. Thomas	97424	1986	198	AR	ASHLEY
NLU	255652	S. Leslie	1184	1985	231	AR	BRADLEY
NLU	287878	E. Sundell	7879	1987	246	AR	CALHOUN
NLU	311881	E. Sundell	9120	1989	259	AR	CLEVELAND
MICH	—	D. Demaree	13698	1933	262	AR	DREW
UNA	969	S. Alley	87720	1977	216	AR	FAULKNER
NCU	6440	G.E. Tucker	6544	1967	252	AR	GRANT

NCU	6456	G.E. Tucker	6552	1967	252	AR	HOT SPRING
MICH	—	S.L. Orzell	3586	1985	296	AR	JACKSON
SFRP	—	P.E. Hyatt	7758	1997	257	AR	LAFAYETTE
MICH	—	S.L. Orzell	3600	1985	297	AR	LAWERENCE
MICH	—	S.L. Orzell	3270	1985	280	AR	MILLER
MICH	—	S.L. Orzell	3675	1985	313	AR	MONROE
SFRP	—	P.E. Hyatt	7765	1997	257	AR	NEVADA
MICH	—	H.E. Hasse	—	1886	275	AR	PULASKI
NLU	92010	D. Lawson	2071	1974	204	AR	SEVIER
SWSL	—	R.D. Thomas	111768	1989	216	AR	UNION
MICH	—	S.L. Orzell	3561	1985	296	AR	WOODRUFF
FLAS	180878	W.J. Dunn	803	1979	184	FL	ALACHUA
FSU	147232	S.W. Leonard	6367	1976	191	FL	CALHOUN
FLAS	154283	J.R. Burkhalter	9029	1983	267	FL	ESCAMBIA
FSU	170546	L.C. Anderson	7774	1984	319	FL	FRANKLIN
FSU	16291	R. Kral	1638	1955	287	FL	GADSDEN
FSU	41867	R.K. Godfrey	57587	1958	246	FL	GULF
NCU	106675	R.K. Godfrey	54257	1955	294	FL	JACKSON
FSU	186078	L.C. Anderson	14518	1993	228	FL	LEON
MICH	—	E.L. Bridges	14469	1990	214	FL	LEVY
FSU	135523	R.K. Godfrey	71631	1972	204	FL	LIBERTY
FSU	147432	R.K. Godfrey	75363	1976	231	FL	MADISON
NCU	6442	S.L. Orzell	12507	1989	264	FL	OKALOOSA
FSU	170885	J.R. Burkhalter	9724	1984	290	FL	SANTA ROSA

FLAS	107048	D.B. Ward	6687	1968	197	FL	WALTON
FLAS	109541	W.H. Duncan	12587	1951	170	GA	BARTOW
MICH	—	R. Carter	6093	1987	225	GA	BEN HILL
SWSL	—	R. Carter	4432	1985	236	GA	BROOKS
TAES	207541	R. Carter	10269	1992	216	GA	BRYAN
MICH	—	A.W. Cusick	6531	1967	256	GA	BURKE
NCU	6563	J.R. Bozeman	10501	1967	177	GA	CAMDEN
SWSL	—	V.E. McNeilus	—	1986	216	GA	CLINCH
US	384434	R.M. Harper	563	1900	246	GA	DOOLY
US	1929636	R.F. Thorne	6677	1947	259	GA	EARLY
SWSL	—	V.E. McNeilus	—	1985	215	GA	ECHOLS
NCU	6601	D.E. Boufford	21688	1979	240	GA	EMANUEL
US	511667	A.J. Pieters	504	1899	227	GA	GLYNN
SWSL	—	V.E. McNeilus	—	1986	217	GA	LANIER
NCU	6602	J.R. Bozeman	1699	1962	279	GA	LONG
MICH	—	J.R. Manhart	143	1980	243	GA	MUSCOGEE
NCSC	103044	N.C. Coile	2298	1981	230	GA	WALKER
MICH	—	R. Kral	85414	1995	221	GA	WHEELER
NLU	331079	C.M. Allen	11021	1981	179	LA	ALLEN
TAES	188984	S. & G. Jones	3803	1989	230	LA	BEAUREGARDE
NLU	—	W.C. Holmes	3675	1979	244	LA	BIENVILLE
DUKE	77974	D.S. Correll	10115	1938	219	LA	BOSSIER
UNA	949	R.R. Haynes	5340	1975	249	LA	CADDO
NLU	337445	L.E. Brown	14942	1990	287	LA	CALCASIEU

SWSL	—	W.C. Holmes	5394	1991	242	LA	CLAIBORNE
NLU	163377	R.D. Thomas	67940	1979	266	LA	DESOTO
NLU	159108	K. Cormier	1156	1978	274	LA	EVANGELINE
NLU	191966	R.D. Thomas	77802	1981	214	LA	FRANKLIN
NLU	73971	C.E. DePoe	64522	1966	228	LA	GRANT
NLU	90037	R.D. Thomas	40213	1974	203	LA	JACKSON
NLU	127439	P. Laird	1488	1975	215	LA	LASALLE
SFRP	5328	R. Smith & H. Grelen	1134	1975	273	LA	LINCOLN
NLU	252549	G.F. Joye	190	1984	272	LA	LIVINGSTON
NLU	28717	R.D. Thomas	16986	1969	277	LA	MOREHOUSE
MICH	—	P.E. Hyatt	6693	1995	199	LA	NATCHITOCHES
NLU	377453	C.M. Allen	18084	1994	254	LA	OUACHITA
NLU	—	R.D. Thomas	5449	1967	276	LA	RAPIDES
NLU	347573	A. Parker	—	1992	232	LA	RED RIVER
NCU	6443	D. Demaree	48375	1963	190	LA	SABINE
FLAS	121564	V.I. Sullivan	1590	1973	227	LA	ST. HELENA
US	1032803	G. Arsene	11500	1919	—	LA	ST. TAMMANY
SWSL	—	F.M. Givens	4413	1985	319	LA	TANGIPAHOA
NLU	321925	R.D. Thomas	119900	1990	214	LA	UNION
NLU	73969	C.E. DePoe	57673	1966	201	LA	VERNON
NLU	225162	D.D. Taylor	5834	1983	261	LA	WASHINGTON
NLU	176803	R.D. Thomas	72135	1980	204	LA	WEBSTER
NLU	149782	R.D. Thomas	61111	1978	263	LA	WEST CARROLL
NLU	193946	K.H. Kessler	1719	1981	249	LA	WINN

MICH	—	C.T. Frye	2080	1999	221	MD	CAROLINE
MICH	—	D. Samson	—	1993	244	MD	DORCHESTER
US	1815716	A. Chase	12631	1940	286	MD	WORCESTER
US	671934	B.F. Bush	6327	1910	255	MO	DUNKLIN
DUKE	358747	M.H. Alford	73	1997	284	MS	AMITE
NCU	6603	J.D. Ray	7134	1956	206	MS	FORREST
SWSL	—	W. Morris	2355	1986	203	MS	GRENADA
SWSL	—	C.T. Bryson	10841	1991	238	MS	HANCOCK
MICH	—	C.T. Bryson	6672	1987	206	MS	ITAWAMBA
SWSL	—	C.T. Bryson	12851	1993	244	MS	JACKSON
NCU	6604	J.G. Teer	—	1963	185	MS	JONES
SWSL	—	S. McDaniel	24552	1980	268	MS	KEMPER
SWSL	—	C.T. Bryson	14198	1994	227	MS	LAMAR
SWSL	—	C.T. Bryson	14966	1995	236	MS	LEFLORE
SWSL	—	C.T. Bryson	10145	1990	224	MS	LOWNDES
US	1923025	W.B. McDougall	1479	1947	253	MS	MADISON
TAES	235371	C.T. Bryson	10152	1990	224	MS	MONROE
SWSL	—	C.T. Bryson	305	1973	231	MS	NEWTON
FLAS	132042	S. McDaniel	12492	1969	300	MS	NOXUBEE
NLU	269764	C.T. Bryson	3440	1982	261	MS	OKTIBBEHA
US	2068063	R.L. Wilbur	3341	1950	193	MS	SCOTT
SWSL	—	C.T. Bryson	12553	1993	215	MS	SHARKEY
TAES	5700	S.M. Tracy	8475	1903	213	MS	SIMPSON
FLAS	76314	J.D. Ray	7490	1956	220	MS	TISHOMINGO

SWSL	—	S. McDaniel	9793	1967	263	MS	WINSTON
NCU	6400	G.S. Ramseur	2917	1956	307	NC	ALAMANCE
NCU	6401	H.E. Ahles	52121	1958	301	NC	BERTIE
DUKE	311103	R.L. Wilbur	38136	1985	230	NC	CHATHAM
NCU	6404	A.E. Radford	40252	1958	253	NC	CRAVEN
DUKE	368481	R.L. Wilbur	69421	1997	270	NC	DURHAM
NCU	6408	A.E. Radford	44476	1961	281	NC	GATES
DUKE	19800	W.T. Batson	554	1951	292	NC	GRANVILLE
NCSC	13456	S. Boyce	2119	1948	297	NC	HERTFORD
NCU	6412	L.S. Beard	983	1955	200	NC	LEE
NCU	6413	A.E. Radford	39431	1958	221	NC	MARTIN
NCU	6414	E.F. Wells	2357	1969	292	NC	MONTGOMERY
UNA	929	A.E. Radford	44342	1961	252	NC	NASH
MICH	—	K.L. McIntosh	12071	1994	246	NC	PENDER
NCU	6421	C.R. Bell	—	1958	224	NC	PERSON
NCSC	14685	W.B. Fox & R.K. Godfrey	2150	1948	302	NC	SAMPSON
NCSC	120066	R. Ingle	735	1992	223	NC	WAKE
NCSC	53197	J.P. Gillespie	20	1955	194	NC	WAYNE
NLU	146420	J. Taylor	23279	1976	241	OK	MCCURTAIN
NCU	6424	W.T. Batson	—	1951	206	SC	AIKEN
NCU	6426	W.T. Batson	—	1952	286	SC	BARNWELL
US	1837755	R.K. Godfrey	1005	1939	212	SC	CLARENDON
NCU	6428	C.R. Bell	5389	1956	285	SC	COLLETON
NCU	6429	C.R. Bell	10809	1957	291	SC	FLORENCE

DUKE	359454	J.B. Nelson	18742	1997	269	SC	GEORGETOWN
NCU	6431	C.R. Bell	4982	1956	252	SC	HAMPTON
NCU	6432	J.A. Duke	94	1957	292	SC	HORRY
NCU	6435	H.E. Ahles	18188	1956	251	SC	JASPER
NCU	6436	C.R. Bell	11049	1957	293	SC	MARION
NCU	6437	A.E. Radford	27506	1957	208	SC	SUMTER
MICH	—	V.E. McNeilus	98901	1998	257	TN	BLEDSOE
UNA	994	R. Kral	40685	1970	229	TN	COFFEE
MICH	—	V.E. McNeilus	95676	1995	264	TN	COOK
MICH	—	K.E. Rogers	40999	1966	287	TN	CUMBERLAND
NLU	194323	T.S. Patrick	2698	1979	243	TN	FENTRESS
LL	—	T. Smith	253	1982	210	TN	FRANKLIN
NLU	408412	V.E. McNeilus	98917	1998	257	TN	HAMILTON
NCU	6446	M. Pyne	93277	1993	276	TN	LEWIS
US	3164923	H.K. Svenson	9519	1938	197	TN	MARION
MICH	—	V.E. McNeilus	931724	1993	223	TN	OVERTON
MICH	—	H.K. Svenson	9658	1938	229	TN	SEQUATOHIE
US	3164924	B.C. Tharp	43268	1944	288	TX	ANGELINA
US	333292	A.A. Heller	4106	1898	227	TX	BOWIE
TAES	188838	S. & G. Jones	3859	1989	294	TX	CASS
TAES	38325	C.L. York	47132	1939	201	TX	GREGG
DUKE	110468	B.C. Tharp	43322	1937	253	TX	HARDIN
LL	293021	J.W. Kessler	5100	1981	261	TX	HARRIS
NCU	6599	R.J. Fleetwood	12231	1976	203	TX	HARRISON

TAES	188692	S. & G. Jones	3827	1989	267	TX	HOUSTON
TAES	77672	F.W. Gould	7318	1956	297	TX	Jasper
LL	293022	B. Ferguson	770	1907	300	TX	LIBERTY
LL	—	D.S. Correll	26408	1962	291	TX	MARION
LL	293020	B. Ferguson	763	1907	299	TX	MONTGOMERY
TAES	10667	H.B. Parks	25929	1937	283	TX	NACOGDOCHES
SWSL	—	S.D. Jones	5669	1990	209	TX	NEWTON
LL	—	S.L. Orzell	12507	1989	264	TX	OKALOOSA
NLU	391506	L.E. Brown	—	1991	0	TX	ORANGE
NCU	6457	E.S. Nixon	5419	1972	276	TX	SAN JACINTO
TAES	221907	E.S. Nixon	16988	1988	189	TX	TRINITY
SWSL	—	T.F. Wieboldt	3182	1977	253	VA	CAMPBELL
NCU	6448	D.M.E. Ware	6485	1975	261	VA	CHARLES CITY
MICH	—	K.L. McIntosh	13021	1996	285	VA	DINWIDDIE
FLAS	141379	J.M. Greaves	1452	1976	237	VA	GLOUCESTER
US	1682819	M.L. Fernald	6551	1936	231	VA	GREENSVILLE
MICH	—	H.H. Iltis	30329	1990	217	VA	ISLE OF WIGHT
MICH	—	T.F. Wieboldt	8787	1996	252	VA	MECKLENBURG
NCU	6451	P.K. Appler	346	1972	287	VA	NEWPORT NEWS
SWSL	—	R. Kral	56511	1975	248	VA	PRINCE GEORGE
SWSL	—	B. Mikula	8045	1950	241	VA	SOUTHAMPTON
US	1682820	M.L. Fernald	6552	1936	232	VA	SUSSEX

APPENDIX F

REPRESENTATIVE ANNOTATED HERBARIUM SPECIMENS USED TO CREATE *CAREX VERRUCOSA* DISTRIBUTION MAPS

HERBARIUM	ACCESCION NUMBER	COLLECTOR	COLLECTION NUMBER	COLLECTION YEAR	JULIAN COLLECTION DATE*	STATE	COUNTY/ PARISH
NLU	363603	J.R. MacDonald	5570	1992	262	AL	HOUSTON
NLU	104987	J. Taylor	16480	1974	186	AL	MOBILE
FLAS	94919	I.L. Wiggins	19737	1965	109	FL	ALACHUA
FLAS	38653	W.A. Murrill	—	1941	144	FL	BAKER
FLAS	194985	E.L. Bridges	21274	1993	79	FL	CLAY
FLAS	77783	L.J. Brass	32731	1960	286	FL	COLLIER
FLAS	47130	A.H. Curtiss	3249	—	196	FL	DUVAL
FLAS	32392	L.E. Arnold	—	1940	108	FL	FLAGLER
FLAS	92367	S. McDaniel	6130	1965	124	FL	FRANKLIN
FLAS	102332	S. McDaniel	8576	1967	77	FL	GADSDEN
FSU	39853	R. Kral	6413	1958	110	FL	HAMILTON
MICH	—	W.P. Stoutamire	1742	1955	320	FL	HIGHLANDS
FLAS	85759	J.A. Lassiter	25076	1962	140	FL	HILLSBOROUGH
DUKE	165719	R. Kral	2874	1956	201	FL	HOLMES
FLAS	38654	W.A. Murrill	—	1941	112	FL	JEFFERSON
US	1028731	P.C. Standley	18952	1919	351	FL	LEE
DUKE	160469	R.K. Godfrey	53496	1955	161	FL	LEON
FLAS	4582	E. West	—	1934	101	FL	LEVY
FLAS	92366	S. McDaniel	6146	1965	124	FL	LIBERTY
FLAS	113471	J.T. Youree	143	1972	113	FL	NASSAU
MICH	—	E.L. Bridges	16723	1991	139	FL	ORANGE
MICH	—	J.B. McFarlin	5662	1931	156	FL	OSCEOLA
UNA	1698	A.G. Shuey	2390	1979	295	FL	PASCO

FLAS	159700	E. Wheeler	—	1985	327	FL	POLK
NLU	413355	C. Slaughter	10862	1999	98	FL	PUTNAM
FSU	98174	S. McDaniel	6102	1965	122	FL	SUWANNEE
DUKE	138831	R. Kral	2427	1956	171	FL	WAKULLA
FLAS	101262	R.R. Smith	1516	1967	171	FL	WALTON
UNA	1617	R.M. Harper	3548	1936	57	GA	EARLY
SWSL	—	T.M. Zebryk	132	1992	104	GA	EVANS
NCSC	51372	R.L. Wilbur	3356	1953	143	GA	IRWIN
TAES	207534	R. Carter	10347	1992	224	GA	LIBERTY
SWSL	—	C.T. Bryson	8021	1988	160	GA	LOWNDES
MICH	—	W.P. Adams	19995	1956	105	GA	MCINTOSH
FLAS	182371	K.A. Williges	46	1993	195	GA	WARE
NLU	189783	C.M. Allen	10684	1981	110	LA	ALLEN
LL	—	S.L. Orzell	7116	1988	151	LA	CALCASIEU
NLU	229034	R.D. Thomas	88087	1984	109	LA	CAMERON
LL	—	J.W. Thieret	25921	1967	119	LA	ST. TAMMANY
MICH	—	S.M. Tracy	—	1898	72	MS	HARRISON
MICH	—	C.T. Bryson	4172	1986	105	MS	JACKSON
SWSL	—	C.T. Bryson	3440	1982	261	MS	OKTIBBEHA
SWSL	—	C.T. Bryson	7065	1987	247	MS	SHARKEY
NCSC	17507	R.K. Godfrey	49189	1949	141	NC	BRUNSWICK
NCU	6396	H.E. Ahles	26225	1957	147	SC	DORCHESTER
DUKE	60312	D.S. Correll	5310	1936	165	SC	GEORGETOWN
DUKE	22834	C.A. Weatherby	16438	1932	112	SC	HORRY

NCU	6398	A.E. Radford	21396	1957	111	SC	WILLIAMSBURG
LL	—	E.L. Bridges	5064	1987	106	TX	HARDIN
TAES	209301	K. Northrup	—	1992	116	TX	HARRIS
TAES	186959	S. & G. Jones	2466	1989	152	TX	JASPER
MICH	—	E.L. Bridges	6458	1988	111	TX	SAN JACINTO

APPENDIX G

JULIAN DATES WITH CORRESPONDING GREGORIAN DATES

JULIAN	GREGORIAN	JULIAN	GREGORIAN	JULIAN	GREGORIAN	JULIAN	GREGORIAN
1 …….	1-Jan	49 …….	18-Feb	97 …….	7-Apr	145 …….	25-May
2 …….	2-Jan	50 …….	19-Feb	98 …….	8-Apr	146 …….	26-May
3 …….	3-Jan	51 …….	20-Feb	99 …….	9-Apr	147 …….	27-May
4 …….	4-Jan	52 …….	21-Feb	100 …….	10-Apr	148 …….	28-May
5 …….	5-Jan	53 …….	22-Feb	101 …….	11-Apr	149 …….	29-May
6 …….	6-Jan	54 …….	23-Feb	102 …….	12-Apr	150 …….	30-May
7 …….	7-Jan	55 …….	24-Feb	103 …….	13-Apr	151 …….	31-May
8 …….	8-Jan	56 …….	25-Feb	104 …….	14-Apr	152 …….	1-Jun
9 …….	9-Jan	57 …….	26-Feb	105 …….	15-Apr	153 …….	2-Jun
10 …….	10-Jan	58 …….	27-Feb	106 …….	16-Apr	154 …….	3-Jun
11 …….	11-Jan	59 …….	28-Feb	107 …….	17-Apr	155 …….	4-Jun
12 …….	12-Jan	60 …….	1-Mar	108 …….	18-Apr	156 …….	5-Jun
13 …….	13-Jan	61 …….	2-Mar	109 …….	19-Apr	157 …….	6-Jun
14 …….	14-Jan	62 …….	3-Mar	110 …….	20-Apr	158 …….	7-Jun
15 …….	15-Jan	63 …….	4-Mar	111 …….	21-Apr	159 …….	8-Jun
16 …….	16-Jan	64 …….	5-Mar	112 …….	22-Apr	160 …….	9-Jun
17 …….	17-Jan	65 …….	6-Mar	113 …….	23-Apr	161 …….	10-Jun
18 …….	18-Jan	66 …….	7-Mar	114 …….	24-Apr	162 …….	11-Jun
19 …….	19-Jan	67 …….	8-Mar	115 …….	25-Apr	163 …….	12-Jun
20 …….	20-Jan	68 …….	9-Mar	116 …….	26-Apr	164 …….	13-Jun
21 …….	21-Jan	69 …….	10-Mar	117 …….	27-Apr	165 …….	14-Jun
22 …….	22-Jan	70 …….	11-Mar	118 …….	28-Apr	166 …….	15-Jun
23 …….	23-Jan	71 …….	12-Mar	119 …….	29-Apr	167 …….	16-Jun
24 …….	24-Jan	72 …….	13-Mar	120 …….	30-Apr	168 …….	17-Jun
25 …….	25-Jan	73 …….	14-Mar	121 …….	1-May	169 …….	18-Jun
26 …….	26-Jan	74 …….	15-Mar	122 …….	2-May	170 …….	19-Jun
27 …….	27-Jan	75 …….	16-Mar	123 …….	3-May	171 …….	20-Jun
28 …….	28-Jan	76 …….	17-Mar	124 …….	4-May	172 …….	21-Jun
29 …….	29-Jan	77 …….	18-Mar	125 …….	5-May	173 …….	22-Jun
30 …….	30-Jan	78 …….	19-Mar	126 …….	6-May	174 …….	23-Jun
31 …….	31-Jan	79 …….	20-Mar	127 …….	7-May	175 …….	24-Jun
32 …….	1-Feb	80 …….	21-Mar	128 …….	8-May	176 …….	25-Jun
33 …….	2-Feb	81 …….	22-Mar	129 …….	9-May	177 …….	26-Jun
34 …….	3-Feb	82 …….	23-Mar	130 …….	10-May	178 …….	27-Jun
35 …….	4-Feb	83 …….	24-Mar	131 …….	11-May	179 …….	28-Jun
36 …….	5-Feb	84 …….	25-Mar	132 …….	12-May	180 …….	29-Jun
37 …….	6-Feb	85 …….	26-Mar	133 …….	13-May	181 …….	30-Jun
38 …….	7-Feb	86 …….	27-Mar	134 …….	14-May	182 …….	1-Jul
39 …….	8-Feb	87 …….	28-Mar	135 …….	15-May	183 …….	2-Jul
40 …….	9-Feb	88 …….	29-Mar	136 …….	16-May	184 …….	3-Jul
41 …….	10-Feb	89 …….	30-Mar	137 …….	17-May	185 …….	4-Jul
42 …….	11-Feb	90 …….	31-Mar	138 …….	18-May	186 …….	5-Jul
43 …….	12-Feb	91 …….	1-Apr	139 …….	19-May	187 …….	6-Jul
44 …….	13-Feb	92 …….	2-Apr	140 …….	20-May	188 …….	7-Jul
45 …….	14-Feb	93 …….	3-Apr	141 …….	21-May	189 …….	8-Jul
46 …….	15-Feb	94 …….	4-Apr	142 …….	22-May	190 …….	9-Jul
47 …….	16-Feb	95 …….	5-Apr	143 …….	23-May	191 …….	10-Jul
48 …….	17-Feb	96 …….	6-Apr	144 …….	24-May	192 …….	11-Jul

193 ……. 12-Jul	242 ……. 30-Aug	291 ……. 18-Oct	340 ……. 6-Dec
194 ……. 13-Jul	243 ……. 31-Aug	292 ……. 19-Oct	341 ……. 7-Dec
195 ……. 14-Jul	244 ……. 1-Sep	293 ……. 20-Oct	342 ……. 8-Dec
196 ……. 15-Jul	245 ……. 2-Sep	294 ……. 21-Oct	343 ……. 9-Dec
197 ……. 16-Jul	246 ……. 3-Sep	295 ……. 22-Oct	344 ……. 10-Dec
198 ……. 17-Jul	247 ……. 4-Sep	296 ……. 23-Oct	345 ……. 11-Dec
199 ……. 18-Jul	248 ……. 5-Sep	297 ……. 24-Oct	346 ……. 12-Dec
200 ……. 19-Jul	249 ……. 6-Sep	298 ……. 25-Oct	347 ……. 13-Dec
201 ……. 20-Jul	250 ……. 7-Sep	299 ……. 26-Oct	348 ……. 14-Dec
202 ……. 21-Jul	251 ……. 8-Sep	300 ……. 27-Oct	349 ……. 15-Dec
203 ……. 22-Jul	252 ……. 9-Sep	301 ……. 28-Oct	350 ……. 16-Dec
204 ……. 23-Jul	253 ……. 10-Sep	302 ……. 29-Oct	351 ……. 17-Dec
205 ……. 24-Jul	254 ……. 11-Sep	303 ……. 30-Oct	352 ……. 18-Dec
206 ……. 25-Jul	255 ……. 12-Sep	304 ……. 31-Oct	353 ……. 19-Dec
207 ……. 26-Jul	256 ……. 13-Sep	305 ……. 1-Nov	354 ……. 20-Dec
208 ……. 27-Jul	257 ……. 14-Sep	306 ……. 2-Nov	355 ……. 21-Dec
209 ……. 28-Jul	258 ……. 15-Sep	307 ……. 3-Nov	356 ……. 22-Dec
210 ……. 29-Jul	259 ……. 16-Sep	308 ……. 4-Nov	357 ……. 23-Dec
211 ……. 30-Jul	260 ……. 17-Sep	309 ……. 5-Nov	358 ……. 24-Dec
212 ……. 31-Jul	261 ……. 18-Sep	310 ……. 6-Nov	359 ……. 25-Dec
213 ……. 1-Aug	262 ……. 19-Sep	311 ……. 7-Nov	360 ……. 26-Dec
214 ……. 2-Aug	263 ……. 20-Sep	312 ……. 8-Nov	361 ……. 27-Dec
215 ……. 3-Aug	264 ……. 21-Sep	313 ……. 9-Nov	362 ……. 28-Dec
216 ……. 4-Aug	265 ……. 22-Sep	314 ……. 10-Nov	363 ……. 29-Dec
217 ……. 5-Aug	266 ……. 23-Sep	315 ……. 11-Nov	364 ……. 30-Dec
218 ……. 6-Aug	267 ……. 24-Sep	316 ……. 12-Nov	365 ……. 31-Dec
219 ……. 7-Aug	268 ……. 25-Sep	317 ……. 13-Nov	
220 ……. 8-Aug	269 ……. 26-Sep	318 ……. 14-Nov	
221 ……. 9-Aug	270 ……. 27-Sep	319 ……. 15-Nov	
222 ……. 10-Aug	271 ……. 28-Sep	320 ……. 16-Nov	
223 ……. 11-Aug	272 ……. 29-Sep	321 ……. 17-Nov	
224 ……. 12-Aug	273 ……. 30-Sep	322 ……. 18-Nov	
225 ……. 13-Aug	274 ……. 1-Oct	323 ……. 19-Nov	
226 ……. 14-Aug	275 ……. 2-Oct	324 ……. 20-Nov	
227 ……. 15-Aug	276 ……. 3-Oct	325 ……. 21-Nov	
228 ……. 16-Aug	277 ……. 4-Oct	326 ……. 22-Nov	
229 ……. 17-Aug	278 ……. 5-Oct	327 ……. 23-Nov	
230 ……. 18-Aug	279 ……. 6-Oct	328 ……. 24-Nov	
231 ……. 19-Aug	280 ……. 7-Oct	329 ……. 25-Nov	
232 ……. 20-Aug	281 ……. 8-Oct	330 ……. 26-Nov	
233 ……. 21-Aug	282 ……. 9-Oct	331 ……. 27-Nov	
234 ……. 22-Aug	283 ……. 10-Oct	332 ……. 28-Nov	
235 ……. 23-Aug	284 ……. 11-Oct	333 ……. 29-Nov	
236 ……. 24-Aug	285 ……. 12-Oct	334 ……. 30-Nov	
237 ……. 25-Aug	286 ……. 13-Oct	335 ……. 1-Dec	
238 ……. 26-Aug	287 ……. 14-Oct	336 ……. 2-Dec	
239 ……. 27-Aug	288 ……. 15-Oct	337 ……. 3-Dec	
240 ……. 28-Aug	289 ……. 16-Oct	338 ……. 4-Dec	
241 ……. 29-Aug	290 ……. 17-Oct	339 ……. 5-Dec	

VITA

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EDUCATION

2000-2003	M.S.	Rangeland Ecology and Management Texas A&M University, College Station, Texas
1995-2000	B.S.	Horticulture Texas A&M University, College Station, Texas Emphasis in Ecology and Botany

HERBARIUM EXPERIENCE

2000-2003	Assistant Curator, S.M. Tracy Herbarium (TAES) Department of Rangeland Ecology and Management Texas A&M University, College Station, Texas Plant identification, curation and management of collections
1999-2000	Herbarium Assistant, Biology Department Herbarium (TAMU) Texas A&M University, College Station, Texas Organize teaching herbarium, mount herbarium specimens

TEACHING EXPERIENCE

2003	Educational Outreach Facilitator, S.M. Tracy Herbarium (TAES), Department of Rangeland Ecology and Management, Texas A&M University, Guide outdoor native plant hikes and lead indoor plant educational activities for area schools
2002-2003	Graduate Teaching Assistant, Department of Forest Science, Texas A&M University, Prepare and teach Dendrology Laboratory
2002	Graduate Teaching Assistant, Department of Botany, Texas A&M University, Prepare and teach Taxonomy of Flowering Plants Laboratory
2001	Graduate Teaching Assistant, Department of Rangeland Ecology and Management, Texas A&M University, Prepare and teach Plant Taxonomy Laboratory

AWARDS & ACTIVITIES

2002	Member of Society of Ecological Restoration, Texas Chapter Attended Joint ESA/SER annual meeting in Tucson, Arizona
2001	F. W. Gould Research Award in Plant Systematics, Research Grant
1998	International Institute of Tropical Agriculture in Ibadan, Nigeria

PERSONAL

1977	Born February 9, 1977
2002	Married Darrel McLaughlin November 27, 2002

ENJOY

Botanizing, Camping, Hiking, Fishing, Mountain biking and Sewing